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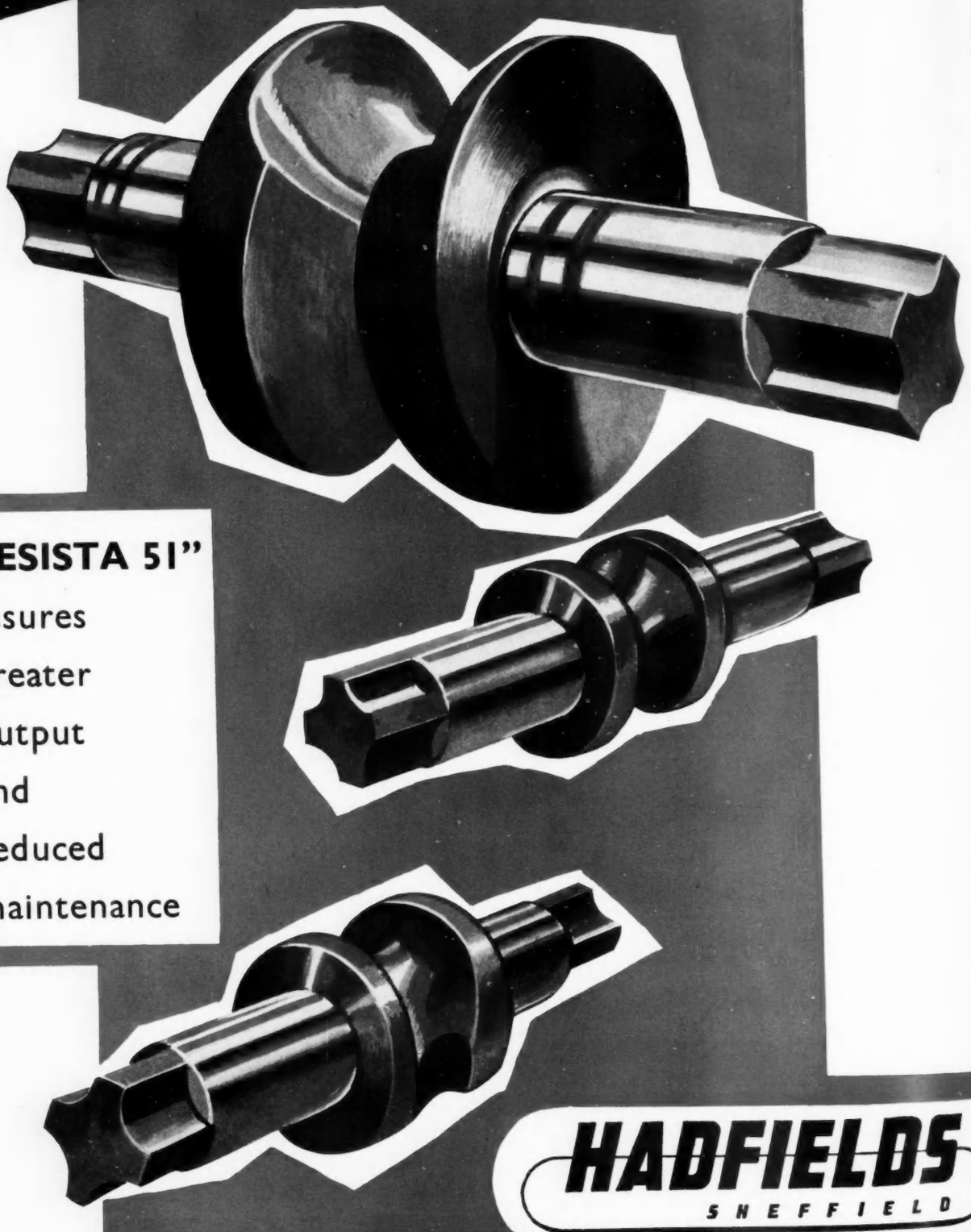

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ENGINEERING

PUBLISHED EVERY FRIDAY

Vol. 185 No. 4805 11 April 1958

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Serious Attention

It is an extraordinary fact that of all the men and women who are taking a public part in arguing about the nuclear dilemma, whether by joining in protest marches or writing letters to the newspapers, very few of them admit that we are confronted with a dilemma. Nine-tenths of them have already decided which course they favour—the moral gesture of renouncing nuclear weapons or the practical politics of retaining the great deterrent—and on that decision they try to base a logical argument to suit their opinions. That the argument of each group is readily pulled to pieces by the other is the clearest indication that there is, indeed, a dilemma—the most appalling dilemma that mankind has ever faced.

As a world power Britain has no longer the economic strength which serves as the foundation for the full exercise of power at the summit. The United States and Soviet Russia alone are in that position. Yet in Britain, with its long history as a great power, its unique part in two world wars, its tradition of political stability and its climate of intellectual and cultural freedom, the nuclear dilemma debate reaches the highest level of which men seem to be capable in the Twentieth Century. Among the people who think about these things, either because they have to or because they like to, the transcending importance of the problem is deeply felt and it is natural for such people to reach a personal decision, however difficult it may be to defend. Sir William Haley, Editor of *The Times*, once labelled this group the Pool of Serious Attention—a hark-back to his days at the B.B.C. where the "P.S.A." was provided for by the Third Programme. He estimated that the P.S.A. consisted of about half a million people, but the number would seem to be greater to-day. It includes, apart from the long-haired fraternity who are stock subjects for ridicule, most of the men and women whose interest in affairs extends beyond their immediate professional interests. Some of them may be tone-deaf or colour-blind, but they like to escape occasionally from the thin diet of popular entertainment which the mass media of communication are obliged to provide. These are the people who mould public opinion; very often they are the only people with intelligent opinions, and to that extent they voice public opinions.

The P.S.A. has always had influence in Britain. In the context of the nuclear dilemma it is more important than ever to allow that influence to reach the country's elected representatives. So long as governments were primarily concerned with defending the country and its people, with promoting healthy trade and a stable economy, and with taking a national view—or at most a Commonwealth view—the Government of the day could be expected to take a reasonable view and adopt reasonable policies which would serve the common interest. The members of the Government owe their position and power to the democratic resolution of vested interests. Broadly, they are bound to serve those interests. The nuclear dilemma, however, is an issue which is far wider than the self-interest even of a nation. Unemployment, or the balance of payments, or any of the other perennial nightmares for Cabinet Ministers, are insignificant compared to it. The Ministers themselves must grapple with the most difficult moral problem of human history, but the process by which they came to power hardly fits them for the task. Their traditional role is to lead a nation; but now the cry is that they should lead the world.

As a nation we can claim to have led the world on several occasions in pre-nuclear times. Then, however, our ability to lead bore some relation to our national preservation and prosperity; now, if we are to lead, we have to forget these factors and show wisdom and statesmanship which ought to be almost super-human. No government can reach this level of statesmanship unless it is backed up by a strong forum of debate and discussion among the P.S.A. Though there are sharp cleavages of opinion—even among men who base their arguments on religious convictions—and though there will be no clear-cut recommendations to put before the Government which cannot be refuted by those who think differently, yet only in that way will the Government know that they can afford to go beyond the normal duties of a British Government. Wide and serious attention is a pre-requisite of effective government action in this field. Britain can offer that. Of the two great powers which hold the centre of the stage, only the United States is sufficiently close to us and known to us for us to be able to look to that nation, as one might look to a friend, and hope that it will use its power wisely. We can be assured by the fact that, however easy it is to speak of American "imperialism," the Americans take a world view of exceptional breadth and understanding. The American P.S.A. is perhaps the most classless and the most dynamic the world has ever known. The Anglo-American P.S.A. is the best hope for humanity.

Cover picture. *The latest—and possibly the last—of Britain's all-weather fighter aircraft, the* P1B, *is the first, in this country, to embody the "weapon system concept"—that is, a unified integration of airframe, weapon-firing control, and enemy identification.*

* * *

Plain Words

Readers of classified advertisements soon become adept at reading between the lines. Whereas Mr. Punch is able to find humour in the lines themselves, the earnest seeker for whom the advertisement has been worded devotes some time, if he is looking for a job, to an exercise in deduction. Assuming the advertisement explains where the appointed person will have to work—information which is not always given—he tries hard to discover whether the box number hides the name of his present firm, how excellent the excellent prospects are likely to be, whether he can claim to be the paragon of knowledge and experience for whom the advertiser is looking, and whether he can argue that his 41 years, though putting him just outside the age limits, are evidence of exceptional experience. The shop-keeper who put a notice in his window, "Smart boy wanted—not too smart," was more explicit than the advertiser who says that experience is essential but omits to say that he is not interested in a man with too much experience.

I am always specially interested in the people who advertise in the Appointments Wanted column. I have yet to see one who has the qualifications and experience for editorial work, but when I do I am sure he will hear from me, because I admire a man who is clearly not given to pulling strings. I admire, too, the firm of consultants who advertised to the effect that, having found it necessary to issue redundancy notices to some of their first-class scientific staff, they invited inquiries from interested employers. In the good old days the redundant man was put on the scrap heap with no more sentiment than a firm would bestow on an old steam engine which they decided to get rid of. But here is a firm who add practical help to the regret with which they dismiss some of their staff. I am reminded of the general commanding a division which had to be disbanded because of very heavy casualties during the Second World War. He had enough worries of his own, but before he cared for himself he spent several days going round various branches of G.H.Q. to see that each member of his staff was posted to a suitable appointment.

Let us rid ourselves of the myth that the successful business man is necessarily a ruthless employer. There have been successful businessmen who have been ruthless employers, but they have left a trail of bitterness and frustration which other more enlightened employers have had to clear up after them. It sometimes takes a generation to clear up the mess. Boycott the ruthless man: his success is bought at too high a price.

CAPRICORN

Weekly Survey

Pruning Priorities

While the Government continues to give every indication of proceeding with its disinflationary policy, the Federation of British Industries has issued a pamphlet called *Fighting Inflation*. This brief restatement, as it is called, includes a seven point programme for curing inflation.

The Federation would first of all cut down Government expenditure because it is through public spending that large sums of money are injected into the economic system. Its second step would be to cut down the supply of money going into less urgent private projects. The third would be to reduce the rate at which money changes hands, what is called the "velocity circulation of money." The pamphlet then passes on to four requirements for raising the output of goods and services. These are to reduce taxation and rearrange the remaining tax to stimulate enterprise, to increase productive investment in industry, to increase personal voluntary saving and finally to persuade everybody in industry, management and workers alike, that efficiency must be increased.

The list brings out one of the basic problems in tackling inflation when we are hurrying to improve our standard of living. It is by no means easy to increase productive investment and at the same time to decide which are the less urgent private projects. It is one of the problems of monetary controls that they tend to disturb the criteria of what are and what are not essential projects. There is a tendency too in these days of state planning, irrespective of what political party is in power, for public investment to receive a high and somewhat artificial priority. In these days there is always the danger that the public will get too many goods and that public corporations and state undertakings will get new capital on unduly advantageous terms while private industry is starved.

Most people will agree with the seven broad headings set out by the F.B.I. to cure inflation. Differences of opinion will arise on their relative importance. There is no doubt that in the last six months the deflationary policy pursued by the Government has won its success by reducing activity in the capital goods industries. The time is fast approaching when the claims of those industries, of which engineering is the main constituent and which receives public recognition for its productive efforts over the last 12 months in the *Economic Survey* 1958 mentioned in another note, must be given the opportunity to expand. The burden of deflation could well be carried in its final stages by the consumer and the Government.

Private Investment Booms

At this time of the year there is no lack of statistical material to show how the economy has behaved in the recent past. The minor deluge of paper from H.M. Stationery Office builds up to the Budget, due on 15 April. The Government's views about the prospect for the rest of 1958 are reserved for the Budget speech, and the White Papers which precede it at the beginning of April do little more than sketch in the recent historical background.

So this year the *Preliminary Estimates of National Income and Expenditure* 1952 *to* 1957 (Cmnd. 398, H.M.S.O., 1*s*.) shows that in 1957 the national income increased by 6 per cent to £19,188 million. Wages and salaries went up in the same proportion while other forms of income receipts did not do quite so well. Consumers' expenditure rose by 4½ per cent and there was a large increase in personal savings. Gross trading profits went up by 5 per cent but the trading surplus of public corporations fell by 4 per cent. Gross investment for fixed assets and stocks went up by 11 per cent and amounted to 21 per cent of the gross national product compared with 17 per cent only five years ago and 11 per cent in 1938. 1957 was in fact a boom year from an investment point of view and the increased savings to balance the increased investment came mainly from private individuals and the Government, not from companies.

The *Economic Survey* 1958 (Cmnd. 394, H.M.S.O., 3*s*. net) which was also released last week shows the Government to be preoccupied with the state of the American recession and the possibility that there may be fairly heavy calls on the central reserves of the Sterling Area this year. The White Paper points out that the investment boom died out about the middle of the year and that the credit restriction policy has had a severe impact on the building and transport industries. Expansion continues to owe much to the resilience of the engineering and metal industries. This year the Government expect exports to be maintained and the policy of credit restriction to have further success in reducing prices. The inference of the White Paper is that, provided the purchasing power of countries producing basic commodities is not further impaired by falling world prices for commodities, this country should continue to have a highly favourable balance of payments in 1958. The Survey is slightly apprehensive that a deepening American recession might not justify such an optimistic forecast. Meanwhile, the Prime Minister said last week at Halifax that there was a reasonable prospect of price stability and that they were ready to take remedial action if the economic climate changed for the worse. His eye was clearly on the world economic situation on the one hand (from which disturbing cold blasts could come this year) and on the home unemployment situation which, though not yet serious, is beginning to be a preoccupation.

Reduce Steam

The order placed by the British Transport Commission for 22 main-line Deltic diesel-electric locomotives follows a prolonged period of test on the prototype locomotive which was delivered in November, 1955. The Deltic, with two Napier diesel engines each rated at 1,650 h.p., is the most powerful locomotive yet built in this country and has achieved some impressive performances on the trials which were conducted on the Midland Region of British Railways.

The British Transport Commission expect these locomotives to cut traction costs by a much greater intensity of use and reduced maintenance as compared with steam locomotives, permitting their working schedule to be based on a much greater annual mileage. The first Deltic, delivered about a year ago, has been running regularly from London to Liverpool and back and then from London to Crewe and back within 24 hours, being in operation for 17 hours out of the 24. This is reflected in the fact that the 22 locomotives now on order will replace 55 main-line steam locomotives on express passenger services. It is understood that eight of the locomotives will operate from Kings Cross, six from Newcastle and eight from Edinburgh.

The locomotives will be built at the Vulcan Foundry Limited, Newton-le-Willows, the engines being supplied by Napier and the electrical equipment by the English Electric Works at Preston. The whole locomotive will thus be built within the English Electric organisation. Deliveries are expected to begin in 1960 and to be completed by mid-1961. Although the price has not been stated, it is believed to be over £100,000 per locomotive, giving a total value for the order of about £2¼ million.

The Vulcan Foundry have already delivered

a number of 1,000 h.p. diesel-electric locomotives (Type 1) under the railways modernisation programme and, at the end of last year, the first of ten 2,000 h.p. diesel-electric locomotives (Type 4) was nearing completion. The company is also engaged on the production of the mechanical parts of 100 electric locomotives ordered from English Electric by the South African railways. These locomotives will also be erected by Vulcan Foundry. Now that an initial order for the Deltic has confirmed the successful conclusion of the trials, it may be hoped that this locomotive will also attract interest in export markets.

State Threatens Italian Industry

Britain is not the only country where nationalisation has been making the headlines recently. For the past 25 years Italy has had a number of state-owned industrial firms and banks under the control of I.R.I. (Institute for Industrial Reconstruction) a state holding company. Last February a new department of state was set up to control and co-ordinate the activities of all the concerns in which the Italian State has any share. The department is under the control of a Minister of State Participation, who since his appointment has been busy sorting out the very tangled threads so that some 300 firms and agencies can be brought under a single control. The issue is complicated by the fact that Italy will be having a general election in May and there is considerable difference of opinion both between and within the parties on how far State participation should go. In the Christian Democrat (Government) party the left wing see the opportunity of controlling investment through the new Ministry. The right wing, however, see further activity by the State as a menace to private enterprise.

One provision of the law which has just come into force requires all I.R.I. controlled firms to withdraw from Confindustria, the General Confederation of Employers. Up to now top managers of State firms have served on Confindustria committees at national and branch level. The decision will affect the giant groups such as Finsider (steel), Finmeccanica (engineering), Finelettrica (electric power), and Stet (telephones), which have hitherto been administered as though they were privately owned concerns. Through Confindustria they took part in wage negotiations with the trade unions and through membership of the various manufacturers' associations I.R.I. industries were represented on branch delegations, missions, and expert committees on national as well as industrial problems. One problem is that new arrangements will have to be made for representation of Finsider in the Coal and Steel Community. Dr. de Michelis, president of Confindustria, has protested at this decision and threatened to place the matter before the Constitutional Court. Whether this threat is carried out or not, a great deal more is going to be heard about the problem of State participation both before and during the Italian elections.

Power on the Continent

The thirteenth session of the Economic Commission for Europe opened at Geneva on 9 April, 1958, and covers a wide agenda. The main business of the Commission will be to consider what action should be taken in the coming year to deal with economic problems affecting Europe in the light of the *Economic Survey of Europe in* 1957, prepared by the Research and Planning Division. In addition, reports will be submitted by a number of committees covering the fields of agricultural problems, coal, electric power, housing, industry and materials, inland transport, manpower, steel, timber and development of trade.

One of the most interesting discussions is likely to be that on European energy problems. A special meeting of Government experts was held from 20 to 26 March to decide what are the principal problems in this field, classify them in order of importance and transmit them to the E.C.E. for a discussion on suitable future action. This is the first time that European energy problems as a whole have been considered by the E.C.E. Some of these problems were set out in the report, *The Electric Power Situation in Europe in* 1956, which was discussed at the fifteenth session of the Committee on Electric Power in October last. They included the growing tendency to concentrate more on thermal power capacity, which is an indication that European reserves of water power are approaching exhaustion; the need to provide for the covering of peak loads, chiefly by pumped storage stations, which will be rendered more attractive by the construction of nuclear power stations; the precariousness of certain countries' power supply during winter months; and the growth of transfer of electric power across frontiers.

Discussion of problems associated with nuclear energy was deferred to the sixteenth session to be held in May, 1958, since the Committee felt that it could not arrange its programme of work on this subject until future relations with the International Atomic Energy Agency had been settled. In the long term, these problems must become of considerable importance; for example, the whole question of the siting of nuclear-energy plants in European countries is likely to present serious difficulties. As in the United Kingdom the number of potential sites has been found to be very limited, some Continental countries will find that the present requirements for cooling water are likely to restrict possible sites to the vicinity of very large rivers and large inland lakes.

Europe's Own Oil Resources

What are the prospects of getting more oil from European sources and breaking the present dependence on Middle East supplies? An O.E.E.C. report, *The Search for and Exploitation of Crude Oil and Natural Gas in the O.E.E.C. Area*, recently published, says that the outlook is bright for rapid increases in supplies of oil from Europe's own oilfields. At the end of 1956 only 12 per cent of oil and gas needs were met from European sources. Production of crude oil alone has risen rapidly from 3·8 million tons in 1950 to 7·9 million tons in 1954. At present rates of progress it should reach 14·5 million tons in 1959. In order to save the increasing amounts of foreign currency needed to import the oil and coal to fill the growing gap in Europe's energy requirements, the O.E.E.C. report urges the all-out encouragement of prospecting for new supplies and their rapid development.

Only a little over one-third of the sub-soil of the West European countries, including Spain and Yugoslavia, is made up of sedimentary basins where prospecting prospects are regarded as favourable. Vast accumulations of oil and natural gas have been found since the war in Austria, France, Germany, Italy and the Netherlands, a number of which have reserves exceeding 100 million barrels and qualify as "large oilfields" in world statistics. Among these are Schoonebeek (Netherlands), Rühle (Germany), Matzen (Austria), Parentis (France) and Ragusa (Italy). From the point of view of energy supplies the natural gas discoveries in the Po Basin (Italy) and at Lacq in France are equally important.

The report concludes that the present modest contribution from European hydrocarbon reserves can be greatly increased. To do this, however, will require the adoption by member countries of administrative and legislative measures likely to stimulate rather than hinder prospecting and exploitation. Another essential will be co-operation at government level for the frequent exchange of information.

Letters to the Editor

DUNDEE JUTE INDUSTRY

SIR, I was more than puzzled by the reference to the jute industry, on p. 386 of your issue of 28 March (Weekly Survey, "Scotland and Technological Change"). You state: "Dundee's troubles are due partly to the high price of raw jute and partly to the long-standing technical conservatism of the jute industry." The first part of the statement is correct; the second part is quite wrong.

The main feature of the Dundee jute industry in the post-war years, indeed, has been its readiness to introduce new technical and management methods. Over £10½ million has been spent by the Dundee jute industry in recent years and that the results have been a complete transformation of methods has been very generally recognised. On the spinning side, the changes have been spectacular, according to a Government source, and virtually no old-type machinery is left. Great improvements in machinery for the preparing processes, and for handling at the various stages, have been made. In weaving, there have been the introduction of a circular loom, the extensive use of the automatic shuttle-changing device for attachment to existing flat looms, and other new and continuing developments. Modern training for all levels of employees and managements has been intensive. The jute industry was the first in Great Britain to introduce a wages structure based on job evaluation. The result of all this change has led to striking increases in productivity. The rise in output per worker compares favourably with the rise for manufacturing industry in this country and is at least double that for textiles as a whole. It is recognised that these technological advances have themselves contributed to the unemployment problem in Dundee, where the need for new industries to take up the surplus labour is urgent.

Reference must also be made to the increasing research activity in the industry. Scientists and technologists in individual firms and in the laboratories of the British Jute Trade Research Association in Dundee have in no small way contributed to the productive efficiency of the industry. At present, four-fifths of producing firms now have their own means of applying scientific knowledge.

I should add that, over the years, numerous references have been made in newspapers, and technical and trade journals to the Dundee jute industry, but your journal is the first that has ever suggested that "technical conservatism" exists in that industry to-day.

Yours faithfully,
ROBERT D. MARSHALL,
Public Relations Officer.

The British Jute Trade Federal Council,
Dundee.
5 April, 1958.

ACCELERATED CURING TESTS ON CONCRETE

SIR, The interest exhibited in the article by Dr. N. G. Bondre and myself (ENGRG., 21 Feb. '58, p. 243) is very rewarding.

In answer to Professor J. W. H. King's inquiry (on p. 324 of your issue of 14 March), the oven used by the Port of London Authority was supplied by the firm of K.C. Productions. It is 17 in deep, 16 in wide, 24 in high and of 3 kW capacity. As illustrated in Fig. 2 of the article, the thermostat was inserted through the lowest of three holes in the oven wall so that it was between the heaters and the cubes. Two thermometers were inserted in the other two openings—their bulbs near, but not touching, the moulds. There is some difference of temperature as recorded by the two thermometers for the first hour or so, but after that period the difference is insignificant.

Regarding Mr. Robert Humphreys's remarks in his letter on the use of a domestic gas oven for

Continuing Letters to the Editor

tests carried out at Birmingham University (ENGRG., 21 Mar. '58, p. 355), the essential requirement of a site test technique is consistency, both in the correlation between the accelerated test results and standard strength tests and in the heating treatment of the cubes. The Authority have selected a good quality thermostatically-controlled electric oven as being the most likely to meet this requirement.

Dr. J. M. Plowman's work on maturity-strength relationships, published in 1956, aroused much interest and, although it was appreciated that the law which he promulgated did not apply to concrete cured above 100° F, the opportunity was taken to use test results obtained for other purposes to see if a similar law applied at 185° F. As stated in the article, the indications are that there is such a law, but a law governing the maturity-strength relationship from temperatures below 100° F, through the intermediate range and up to 185° F, was not found. The work carried out in the Port of London Authority on this subject was very limited and publication of the results of the further investigations referred to by Dr. Plowman in his letter (ENGRG., 4 Apl. '58, p. 419) is keenly awaited.

The Port of London Authority have now included the accelerated curing test in the concrete specification for a project shortly to be commenced. Its efficacy will be closely watched. In the meantime, work will be continued on the development of the test to ascertain the effects of small variations in the period elapsing before the cube is placed in the oven, small variations in the heating period, and other small variations likely to occur on a works site.

Yours faithfully,
N. N. B. ORDMAN,
Divisional Engineer (Plans).

Port of London Authority,
London, E.C.3.
26 March, 1958.

ELECTROMAGNETIC PUMPS

SIR, If I may be allowed to revert to the matter of the efficiency of electromagnetic pumps for liquid metals (my letter in your issue of 7 September, 1956), I have noticed an apparent discrepancy between the ohmic resistance of a 14 h.p. linear a.c. pump given by Dr. L. R. Blake of B.T.H. in his letter in ENGINEERING for 19 October of that year, and that of a pump the performance details of which were given in a paper entitled "Conduction and Induction Pumps for Liquid Metals," published by the Institution of Electrical Engineers in July, 1956.

In the first pump using sodium the "ohmic resistance," which is understood as an I^2R loss, is given as 28 per cent. In the latter pump, using 22/78 NaK at 175° C the same loss is given as 2·77 kW out of a total input of 8·60 kW which works out at 31 per cent. These two pumps are about the same size and type: the specific resistance of liquid sodium at 175° C is 12·4 μ per c.c., whilst that of the sodium-potassium alloy is 45·5 μ per c.c., or 3·66 times larger. If, however, we ascribe 25 per cent of the resistance loss to a heating effect due to increased molecular motivity when the metal is in motion and traversed by the current, these figures begin to appear reasonable. Instrument readings would not, I suggest, normally distinguish between the two types of "resistance" loss. We have therefore to advance a theory to account for the discrepancy disclosed above. Suppose we split up these two resistance losses of the Na and the NaK alloy to conform to theory:—

Then:

	Kinetic heating by extra motivity given to ions, per cent	"Ohmic" losses, per cent	Total per cent
Sodium	25	3	28
Sodium-potassium	25	6	31

This result is more in line with what you would expect considering the much lower specific resistance of the pure sodium. Even liquid copper should give at least 25 per cent loss, or, more probably, 26 to 27 per cent at the higher temperature. Mercury having twice the resistivity of the NaK, viz. 93 μ per c.c., would give a 25 + 12 or 37 per cent loss, which is one reason why sodium is preferably used in these pumps.

Practical tests on pumps have given figures well below the calculated value—about 75 per cent or so, and this has been taken to be due to some not directly measurable factor at work such as "contact resistance" between the moving liquid and the walls through which the current passes. But why this should give so much resistance loss is not easy to see. However, perhaps any "unknown" is good enough to explain another "unknown." It seems to me that the whole theory of liquid metals in motion relatively to transverse magnetic fields needs considerable clarification. I have not as yet seen reports of experiments in which liquid metals have been used to generate current. The results of such experiments should prove illuminating, since unlike solid conductors when only the electrons are set in motion (the positive ions of the metal merely oscillating about fixed positions), with liquids, or even an ionised gas like mercury vapour for that matter, the positive ions are themselves set in motion in the opposite sense and direction to the negative electrons through the interaction of the electrostatic and magnetic fields. How then can we say that an electromagnetic force is exerted on the liquid metal in the same way as on a solid conductor. In a generator, I should say that the kinetic action of the ions would act reciprocally to the way in which they operate in motoring.

Yours faithfully,
H. J. NORTHFIELD.

332 Bramford Road,
Ipswich.
2 April, 1958.

Plant and Equipment

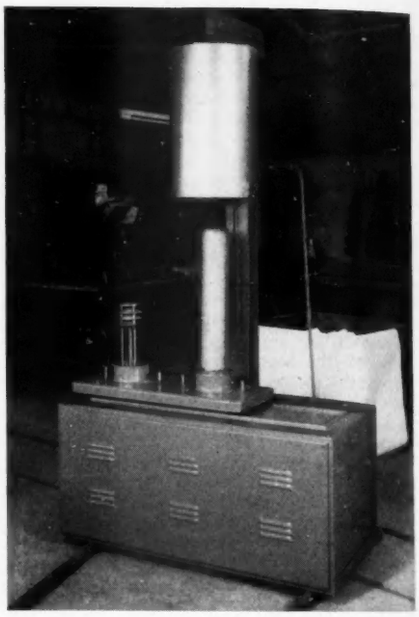
HYDROGEN BELL FURNACE FOR HEAT TREATING

Typical of a number of small furnaces specially designed and manufactured by Royce Electric Furnaces Limited, Sir Richard's Bridge, Walton-on-Thames, Surrey, for individual requirements in the electronic and allied industries, is the hydrogen bell furnace shown in the accompanying illustration. The charge to be heat-treated is stacked upon one of two identical bases, mounted, as may be seen, upon a traversing trolley, the work space available being 5 in. in diameter and 13 in. high. Each base embodies gas seals, heat-resisting steel heat baffles and hydrogen (or other protective gas) inlet and outlet. When stacking is complete, a heat-resisting steel gas-tight hood or "retort," having a sealing ring to engage with the gas seal in the base, is placed in position over the charge. Hydrogen is then introduced through the base and ascends to the top of the retort completely purging the work chamber of oxygen.

When the chamber is finally purged the pneumatically-operated cylindrical bell furnace is lowered over the retort. The hoisting gear is counter-balanced and worked by a double-acting air cylinder furnished with operating valves and speed-control mechanism. Heating elements of 80:20 nickel-chromium surround the heating chamber, giving a uniform heat transfer throughout, and suitable for operation at temperatures of up to 1,000 deg. C. To give a long service life, the heating elements operate from the low-voltage secondary of a step-down transformer, permitting the use of a heavy-section element. The body of the furnace is insulated within its cylindrical casing, thus reducing heat losses to a minimum.

For the regulation of the temperature, two fully-automatic temperature controllers are provided, with a thermocouple in the heating bell and one in each base. A change-over switch is fitted for use with either base.

During a heating cycle, the adjoining base may be loaded up and purged and, when the heating cycle of the first base is completed, the heated bell is raised and the base trolley traversed to bring the second base to the heating position. The bell, retaining its sensible heat, is then lowered over the second retort while the first charge is allowed to cool in its protective atmosphere.



The charge to be heat-treated is arranged on one of two traversing bases which is then covered by a gas-tight hood or "retort." The enclosed chamber is purged of oxygen by hydrogen, and the heating bell lowered over the retort.

As may be seen from the illustration, the furnace apparatus is mounted upon a steel stand having louvred removable panels providing convenient accommodation for the switchgear and transformers.

Larger furnaces of this type, having chamber sizes up to 3 ft. in diameter by 5 ft. high for operation at temperatures of up to 1,150 deg. C., may be supplied.

PRESSURE CENTRIFUGES

Three new centrifuges were introduced by Sharples Centrifuges Limited, Tower Works, Camberley, Surrey, at the 26th Exposition of Chemical Industries in New York. The first of these is a high-capacity vertical decanter-type machine for pressure operation, handling slurry feeds in the range of 200 to 250 gallons per minute, and solids discharged up to 10 tons per hour. Pressure and vapour-tight models are available as well as the standard open version. The second is a nozzle-type machine with a 30 in. diameter bowl for clarifying, separating or solids concentration at rates up to 300 gallons per minute or more, and the third is a horizontal decanter which rotates at 4,000 r.p.m., and is designed to handle slurries in suspension.

Continuing **Plant and Equipment**

TELEVISION HAND CAMERA

Transistors Reduce the Weight

Television outside broadcasts will be made more realistic by the latest development in television cameras, appropriately named the "Peepie Creepie." Like its cousin in the field of radio-communication, the Walkie-Talkie equipment, it is carried by the operator and enables picture signals to be transmitted over relatively long distances without cable linkage.

Associated-Rediffusion Limited used this equipment for the outside broadcast from the Brands Hatch motor racing circuit on Easter Monday when the camera, mounted in a Lotus 7 car driven by John Cotter of Independent Television News, took viewers with the competing cars on the "warming up" lap at speeds of up to 80 m.p.h.

The miniature camera and its portable equipment are manufactured in France by Compagnie Générale de Telégraphie Sans Fil, Paris. The camera measures only about 7½ in by 4 in by 4 in and can be carried by hand. With the control unit, power pack, and transmitter the total weight is only 60 lb—light enough to be carried on a cradle strapped to the camera-man's back. Previous drawbacks to outside broadcasts were the weight and unwieldiness of the normal camera and control units, which could only move within the 1,000 ft radius of the transmitter cable link. The new equipment goes a long way to overcoming these technical difficulties and provides opportunities for developing new outside broadcast techniques since the operator's freedom of movement is no longer restricted.

The camera, which is held in the hand, contains a standard Vidicon pick-up tube, standard 16 mm optical lens system, scanning and focusing coils, and a two-valve video pre-amplifier. There is an optical viewfinder attached to the side of the camera, and a zoom lens is provided for use, if desired, as an alternative to the interchangeable fixed lenses.

A short flexible multi-cable connects the camera to its control unit, which forms a separate portable unit comprising the control unit proper, synchronising generator, and a low-power transmitter. The control unit itself contains the main video-amplifier, scanning and sync pulse generators, mixing circuits and pre-set controls. The controls provided are: target voltage, beam current, black level, video gain and picture size, hold and shift controls. An interesting feature of the design of the synchronising generator is the use made of transistors—it contains 32 transistors and 42 germanium diodes, which are the equivalent of 74 valves in older designs—so that it is small enough to be built into the lid of the control unit. The function of this unit is to supply timing pulses to the control unit for the purpose of triggering the scanning, blanking and sync pulse circuits, so that the various components of the picture signal are put together in the correct sequence. The low-power 100 mW transmitter feeds to the aerial and the resulting signal may be picked up within a distance of about 100 yards. For all these purposes, the control unit uses only 11 valves.

The power unit contains a transistorised high-tension unit and a miniature 12 volt battery (consisting of two "Andyar" 6 V silver-zinc units) giving a running time of 3 to 4 hours. When a longer range of a mile or so is required a 5 W transmitter is used with a similar type of

power unit. These two units, with the small flexible aerial fitted to the top of the transmitter, may be mounted on top of the other units when carried as a pack, as illustrated.

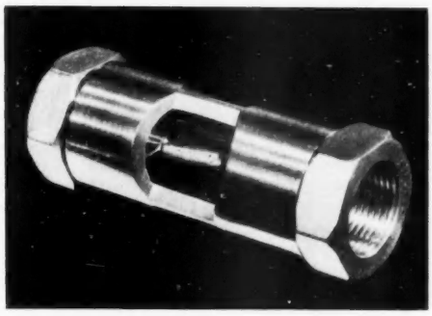
It was necessary to construct special receiving aerials giving the desired characteristics of direction and gain and in this work considerable assistance was given by Wolsey Electronics Limited, Orpington, Kent.

The complete equipment radiates a standard television signal a distance of a mile or more, where it may be fed to the relay frame in the "scanner" or outside broadcast van, selected by the programme director and passed on to master control at Television House.

MOBILE RADIO

The latest addition to the "Ranger" series, manufactured by Pye Telecommunications Limited, Cambridge, is a heavy-duty equipment for long range working. Transmitter powers up to 20 watts with frequency modulation are available and the equipment is designed to fit into a vehicle, boat, or railway locomotive. The main unit, which is the size of a small suitcase, can be installed in the boot of a car, while the control unit can be mounted on the dashboard. The new equipment is produced in four main types: 5 and 15 watt amplitude-modulated versions; and 10 and 20 watt frequency-modulated versions. The amplitude-modulated equipments will operate on channel spacings from 20 to 100 kc/s, and the frequency-modulated equipment will operate on 50 kc/s spacing. All equipment will operate on single- or double-frequency simplex or duplex on fixed frequencies in the band from 25 Mc/s to 174 Mc/s. Models with up to six switch-selected channels are available.

VISUAL FLOW INDICATORS

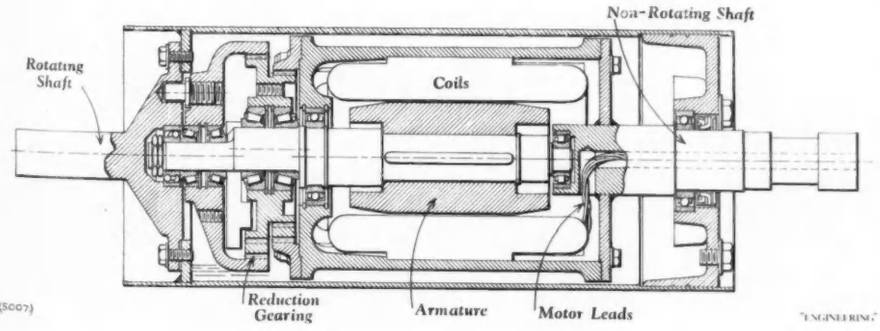


The Telicator range of flow indicators made by the Dukes and Briggs Engineering Company, Limited, Altrincham, is now being distributed in this country by Sir W. H. Bailey and Company, Limited, Albion Works, Patricroft, Manchester. They are visual indicators to show if flow is actually occurring; the rate can be judged by the comparative speed of rotation. One example is shown in the accompanying illustration.

The rotor is mounted in jewelled bearings and the flutes are formed to suit the specified rate of flow and the viscosity of the liquid. They are equally suitable for use in high- or low-pressure systems and for high or low rates of flow. There is a variety of models to suit widely varying installations, and there is also a special version for opaque liquids.

BUILT-IN CONVEYOR DRIVE

A drive for a conveyor belt in which the motor has been incorporated in the drum has been developed and put on the market by T. and T. Works Limited, Billesdon, Leicester. Known as the Thorite, 13 models are available, the largest having a drum diameter of 18 in and a rating of 15 h.p. Belt speeds are up to 250 ft per minute according to size.



The construction of the drum is shown in the accompanying illustration. The leads to the squirrel-cage motor are fed in through a stationary shaft at one end: the shaft the other end rotates and must be mounted in a bearing. With this arrangement there is no need of slip rings to feed the motor. The motor is geared down to drive the drum and the gear ratio can be varied. A typical example is for the 8 in drum size with a 1·5 h.p. motor which can have gear ratios to give belt speeds of 25, 50, 100 or 175 f.p.m. Sealing plates at both ends of the drum enclose the motor and gearing together with the lubricating oil.

ELECTRICITY ON SHOW

In the absence (due to pressure of work) of Sir David Eccles, the seventh Electrical Engineers Exhibition at Earl's Court was opened by Mr. F. J. Erroll, Parliamentary Secretary to the Board of Trade and a former Metropolitan-Vickers apprentice. In his speech, Mr. Erroll drew attention to the ways in which electricity was helping to improve the health of the nation, not only in medical services, as was being shown in the Electricity in Hospitals section, but by reducing atmospheric pollution and improving living conditions generally.

The sponsors of the exhibition, the Association of Supervising Electrical Engineers, must be very proud to see the growth of their seven-year-old. Of the specialist exhibitions that have grown up since the war, it is the largest and if past records are any criterion, one of the most popular among buyers and exhibitors. It even has a daily newspaper of its own. Details of some of the exhibits were given in our issue of 14 March and some more are briefly described below. More than 70,000 attended during the five days.

In the Electricity in Hospitals display, 294 items were listed in a separate catalogue, apart from furnishings and kitchen equipment. The display was divided to represent the different sections of a hospital: the ward, the theatre, X-ray and radiotherapy departments, the dental clinic, sterilisation room, kitchens and the like. The Newton-Victor Orbiton cobalt therapy unit, of which a quarter-scale model was being displayed, has already been described in an earlier article. Part of the section was staged by the Electro-Medical Trades Association.

MAGNETIC TRANSFORMER

A split-core current transformer that can be snapped around any cable was one of the many types of transformer shown by Smith Hobson Limited, Hersham Trading Estate, Walton-on-Thames, Surrey. It is illustrated in Fig. 1. The two parts are held together by permanent magnets moulded into the polyester casing,

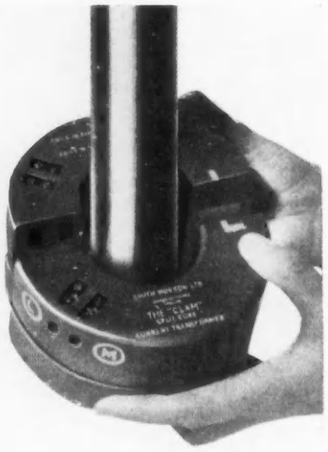


Fig. 1 The Clam metering transformer is held in place on the cable by built-in magnets.

and can be supplemented by clips for permanent installations. They exert a force of 30 lb on the core joints and it is most important to see that the faces are clean. The Clam is made in three models, each with two ratios obtained by altering the external connections, covering the range from 200 : 5 to 800 : 5 A. The highest ratio model has a rating of 15 VA at 50 c/s. Dimensions are 2½ in inside diameter, 5⅝ in outside diameter, and 2¾ in thick. The weight is 7½ lb.

HANDYMAN WELDER

To meet the need of the home handyman and the small workshop, the Ballard arc-welder has been developed by the Ashton-Young Engineering Development Company Limited, 76 Cambridge Road, Kingston-on-Thames, Surrey. It was shown on the stand of Slough Metals Limited. The complete equipment as sold is shown in Fig. 2, and consists of transformer unit, electrode holders, eye shield, scratch brush and chipping hammer. Three current outputs are provided ranging from 25 to 85 A. Steel up to 20 s.w.g. can be welded at high speeds and electrodes between 12 and 16 gauge can be used. Power is obtained from the mains at either 190 or 250 volts, drawing from 5 to 15 A. primary current. The transformer unit is enclosed in an aluminium case measuring 11 in by 11 in by 10½ in, and weighs 30 lb. A carrying handle is formed on the top of the case.

Fig. 2 For home or workshop, the Ballard unit will weld steel up to 20 s.w.g. at high speed.

PRESSURE SWITCH

A range of control switches made up the main part of the exhibits of Delta Technical Services Limited, Cowleaze Road, Kingston-on-Thames, Surrey. It included pressure and vacuum switches of all types as well as thermostats and flow-operated models. Two which have been developed since the last exhibition are a general purpose pressure switch and a flame-proof version certified for gases in Groups I, II, and III. Models of both are available for pressures from a few inches water gauge up to 10 tons per sq. in, or for vacuum service. The example shown in Fig. 3 has an operating range adjustable from 10 to 150 lb per sq. in, or for a differential of 11 lb per sq. in. The contact rating is 5 A at 240 V a.c. or 2 A at 440 V a.c.

VIBRATION METER

Exhibits by the Brush Electrical Engineering Company Limited, Loughborough, ranged from a full-size locomotive cab to a vibration meter. The latter is intended for the investigation of a wide range of problems and is designed for use with a velocity-sensitive pick-up head with a sensitivity of approximately 770 mV per in per sec. Battery-operated, the instrument is completely portable and covers the following ranges: displacement 0 to 0·1 in in four switched ranges, and velocity from 0 to 10 in per sec in three switched ranges. The frequency range is from 10 c/s to 4 kc/s except for the lowest displacement range for which it is from 50 c/s to 4 kc/s. The accuracy is within 5 per cent over a temperature range from 0° to 50° C.

Basically the instrument is a high-gain amplifier using junction transistors, the output of which is integrated for direct reading on a sensitive meter. Power is supplied by two 9 volt dry batteries which give an operating life of about 400 hours.

Fig. 3 This pressure switch is adjustable to operate at pressures between 10 and 150 lb per sq. in. A flame-proof version is also available.

REMOTE COMMUNICATION

Another item shown by the same firm was a signalling and remote control system using digital computer techniques. One advantage is that the Multiplex uses only two pairs of conductors fed by a master controller and tapped by slave units. Information is transmitted along one cable by a repetitive train of pulses made up of two synchronising pulses for each channel followed by an information pulse. Thus one complete information channel comprises two synchronising pulses and spaces for two information pulses. For correct operation either one pulse A or the other pulse, B, must be present. If neither or both occur a fault exists. Thus a two-state control is available with direct indication of each state. A fault opens a ring circuit and sounds an alarm.

The slave unit selects its particular signal through the synchronising pulses, and its output then operates in one of two ways according to whether an A or B signal has been transmitted. These relays may be used for direct control providing the maximum load does not exceed 0·75 A at 40 V. A set of change-over contacts in the slave station then returns an indication of the action to the main station. To avoid interference, the receiver relay circuits are set to operate on the summation of several pulses, and filter circuits at the receiver input terminals centre the bandpass closely on 1,000 cycles. The slave stations may be up to ten miles from the master without the need for repeaters. All stations are battery powered or fitted with built-in supply units. Junction transistors and germanium diodes are used throughout in conjunction with printed circuit plug-in boards.

RING MAIN UNIT

A new non-extensible ring main unit was among the exhibits of Johnson and Phillips Limited, Charlton, London, S.E.7. Known as the type NX, it has a current rating of 400 A at 11 kV with the switches rated at 250 MVA. Either plain break or arc-controlled oil switches can be fitted as desired. The complete unit is shown in Fig. 4. The T-off breaker is a standard item and can be fitted for manual operation,

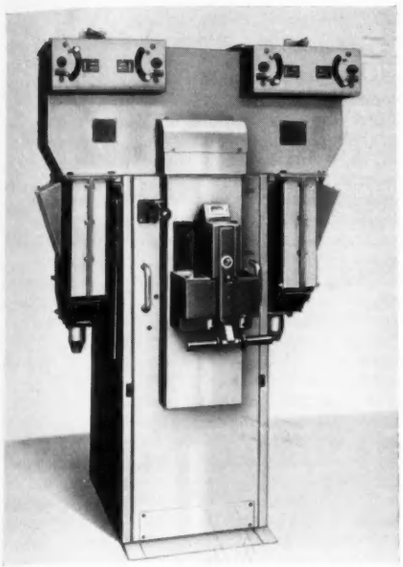


Fig. 4 The NX non-extensible ring main unit.

spring assisted, spring or solenoid operation.

The switches on the incoming cables are oil filled and spring operated from detachable handles. Each is arranged to provide "off" and "earth" positions using two sets of blades. The mechanisms are interlocked through the common spring that is used to operate both. Means are provided for inserting cable test plugs through the top covers but only when the switches are in the earth position. The springs ensure that the switches operate at the correct speed independently of the speed of the operator.

CONCRETE HAND DRILL

The Vibroto electric drill (Fig. 5) shown by the Rawlplug Company Limited, Rawlplug House, Cromwell Road, London, S.W.7, has been designed particularly for drilling holes rapidly in concrete. Its special feature is rapid penetration through a pebble aggregate. The machine is made up from two main units, a portable electric drill and gearbox, and a vibrating head which can be clamped on. The force and speed of vibration can be selected by turning a knurled ring which has three positions. These give: rotary movement only; light rapid vibrations; or heavy slow vibrations coupled with the rotary movement. The trigger switch can be locked on for continuous drilling.

Hard tipped tools with negative cutting angles are available for use with the drill and any size between Rawlplug number 6 and 20 can be accommodated. The machine weighs 9¾ lb and has a chuck speed of 940 r.p.m. It runs off standard voltage and the consumption is about 310 watts.

SUPERVISORY SYSTEM

Standard Telephones and Cables Limited, 63 Aldwych, London, W.C.2, were showing examples from most of their range of products. Among the items was the Simple supervisory system designed for remote communication and operation, using sets built to a standard pattern which would be available "off the shelf" and made up of interchangeable parts. The control station wall panel is shown in Fig. 6.

Each panel affords the remote indication of up to 15 separate electrical contacts which can be arranged in pairs if desired to give on/off indication of motors, switches and the like. Similarly, remote operation of these 15 contacts can be made. There is a two-way telephone circuit between the main and remote stations and provision is made for circuit testing. On the main station panel is a blank plate on which the diagram of the remote station can be drawn with a wax pencil or permanently engraved.

In operation any change in the condition of any one of the remote contacts is indicated on the main panel and a warning is sounded. A beacon lamp also lights. The basic system is designed to operate over one pilot pair with a maximum loop resistance of 2,000 ohms. Alternatively, without modification, two such pairs can be used. The advantage of the latter arrangement is that signals can be sent and received simultaneously. All the apparatus is suitable for operation from the standard mains at either 100 or 250 volts 50 cycles.

SILICON RECTIFIERS

The same firm were also showing a silicon diode cubicle, one of 12 for an electro-chemical extraction plant in South Africa. Each cubicle houses four hollow busbar assemblies on which are mounted 48 silicon diodes. The 12 cubicles are arranged in four three-phase bridge circuits with their outputs connected in parallel. The total output rating is 20,000 A at 130 V. Cooling is provided by circulating oil through the hollow bars and through an oil-to-water heat exchanger. The input is from the 6·6 kV line and the equipment will have to operate at an altitude of 5,500 ft and in an ambient temperature of 40° C. The estimated overall efficiency of the rectifier is 94·2 per cent.

ICE WARNING SET

One of the items on the stand of Sangamo Weston Limited, Great Cambridge Road, Enfield, Middlesex, was a warning system to indicate to pilots of aircraft when the atmospheric conditions were such as would cause icing. The system can either be used purely as a warning by indicator lamps or other means, or it can be adapted to take the necessary action in order to prevent the formation of ice on the aircraft.

In principle, it depends on the fact that icing can only occur when the temperature is below freezing point and the atmosphere contains

Fig. 5 The Vibroto incorporates light or heavy percussions with a rotary movement.

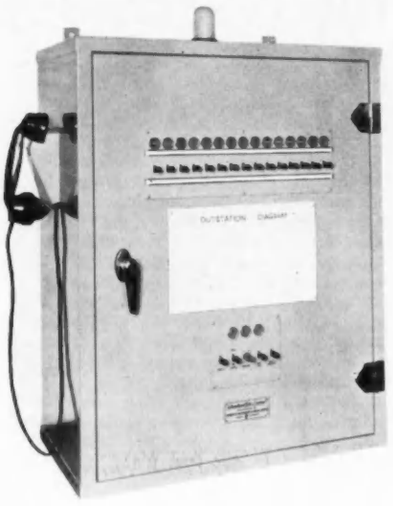


Fig. 6 The Simple supervisory system, which is made up of packaged panels, will give indication and control up to 15 separate contacts.

moisture. Therefore two detector heads are employed, one of which measures the temperature and the other the humidity by what are virtually wet and dry bulb thermometers. The signals from these detectors are summated in a control unit and the output signal from the latter is used to give the appropriate warning. When lights are used there are three, one showing freezing temperature, one water in the atmosphere and the third, which lights when both the others are on, the existence of icing conditions.

WARD-LEONARD TRANSISTORISED SET

Shown for the first time, at the exhibition, was the Transidyne transistorised Ward-Leonard set. This has been developed by Lancashire Dynamo Electronics Limited and was shown on the Group stand. As may be seen in Fig. 7, it is made as a packaged unit with the motor-generator set on anti-vibration mountings. The use of transistors not only cuts down the size of the complete set but also gives a high-performance closed-loop servo control. Plug-in printed circuit design has been used and the whole cubicle is cooled by the motor fan. Regenerative braking is also incorporated.

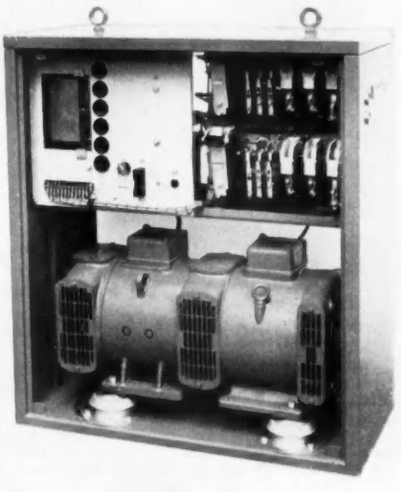


Fig. 7 The use of transistors makes a compact packaged Ward-Leonard set.

BRUSSELS FAIR BEFORE THE OPENING

The opening day of the Brussels Universal and International Exhibition approaches. Most of the main constructional work has been completed. Now interiors are receiving close attention and last minute adjustments are being made to exhibits.

Thursday 17 April is the opening day. The official ceremony will take place in the presence of His Majesty The King of the Belgians. At 10.30 a.m. the official session will begin in the main auditorium of the exhibition. Members of the Government, high officers of the Realm, heads of Diplomatic Missions and Commissioners-General of the 53 participating countries will be present. Later The King will visit the exhibition, preceded by the Royal Escort, accompanied by his suite.

" As regards our own share in this gigantic undertaking," said Sir John Balfour, the United Kingdom Commissioner-General for the Brussels exhibition: " In the first place our site of 4½ acres was deliberately chosen in 1955 because of its dominant position and because it is the largest area in a part of the exhibition grounds which possesses features reminiscent of an English park.

" Secondly, whereas most of the other exhibiting countries have tended to concentrate on erecting one pavilion, our site possesses two. The one has been organised by the Central Office of Information and constructed out of public funds: the other, organised by the F.B.I., is entirely financed from private sources. These pavilions are themselves in pleasing contrast with each other. Thus the three tall crystal-shaped spires that surmount the entrance hall of the official pavilion are the reverse of functional. Their unusual appearance cannot fail to lure the visitors into our section. After dark, the windowless outer walls of the pavilion are ingeniously lit to form jewelled carpets of scintillating light. By contrast, as befits its contents, the large industries pavilion confronts visitors with an immense show-case of plate glass which, after nightfall, reveals a brilliantly illuminated interior.

" Although the contents of the two buildings complement and reinforce one another, I would say that, broadly-speaking, the Government and Industry pavilions in turn reflect the twin themes of the exhibition. The first illustrates Man and his Aspirations; the second is devoted to a display of Techniques in the Service of Man. The two sides of our exhibit unite to give an impressive and inspiring picture of contemporary Britain."

One of the pyramid buildings of the Government pavilion is shown in Fig. 2. This and other illustrations shows the state of construction at the end of March. Fig. 1 gives a general view of the exhibition and shows the advance state of construction of many of the items. On the left can be seen the atomium; pointing towards it is the 240 ft mainstay of the Belgian civil engineering structure. Figs. 3 and 4 show the United States and the Austrian pavilions. Under the latter can be seen a 43 ton ball of stone—it is from Austria, and is of the material that magnesium is extracted from.

The British industries pavilion (Fig. 5) is a sealed exhibition showcase. The walls are entirely of glass with a new system of curtain walling. Nearly 33,310 sq. ft of plate glass is used. The non-distorting finish to the glass can be appreciated by the regularity of the reflected image. About 60,000 sq. ft of floor area is available.

The largest single exhibit within the pavilion is the collective exhibit of the British Electrical and Allied Manufacturing Industry. Entitled " Power for Progress " it will occupy about one-eighth of the available exhibition area in the pavilion. The design is intended to form a composite pattern which will almost constitute a small pavilion within the British industries pavilion. About half the area will be built up to a height of over 20 ft, raising the total effective area to about 6,500 sq. ft.

Along one side of the exhibit will be three chambers of energy—thermal power, nuclear energy, and water power—together with connecting links. An animated three-dimensional exhibit will show how electricity serves industry—from A to Z (aircraft manufacture to zinc mining). Britain's prominent part in the invention and development of radar and electronics will be stressed by a special electronics exhibit that will

Fig. 1 The construction of the Brussels Universal and International Exhibition nears completion. In this general view, taken at the end of March, the atomium can be seen on the left.

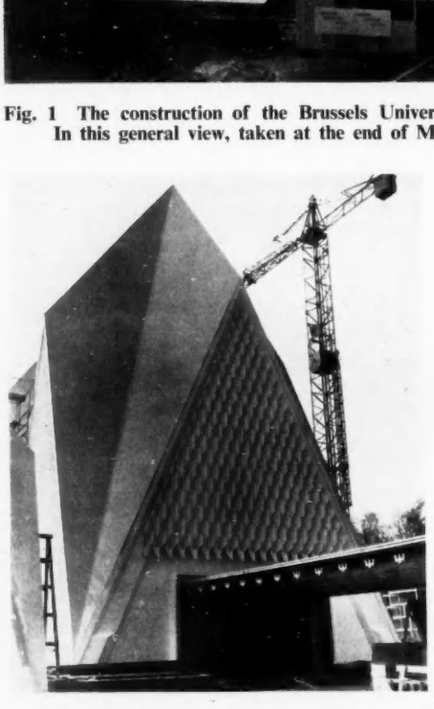


Fig. 2 The entrance to one of the pyramid buildings of the British Government pavilion. The walls are windowless. Interior lighting is by many green and purple wall lights.

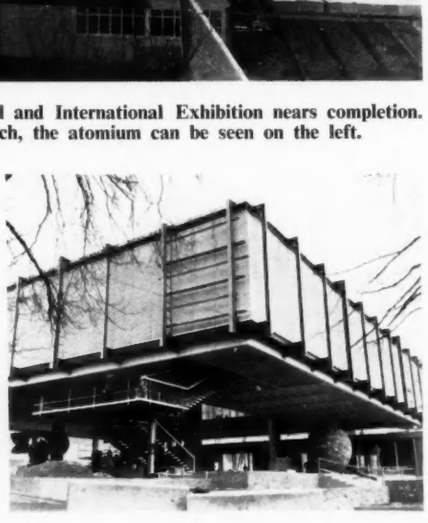


Fig. 3 (above) The main work on the Austrian pavilion is complete. The large ball is of the stone from which magnesium is extracted.

Fig. 4 Circular in plan, the United States pavilion is 340 ft in diameter. Its walls are of cellular plastics honeycomb, attached to steel columns.

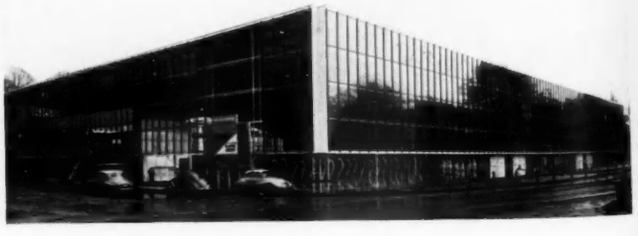


Fig. 5 (right) The British industries pavilion is a glass showcase, which will display a wide range of British engineering achievement.

have as its central feature a 18 ft high tower made up of over 1,500 valves of British make. Upstairs will be a domestic and radio section.

Many British light and medium engineering industries will be represented by the products of some 85 firms displayed on the stand of the Birmingham Engineering Centre. The stand has no solid walls and many of the exhibits will be suspended. It is a two-storey welded structure with Oregon pine floors. Open staircases are sited at each end. An example of the sort of exhibit that is to be found on the stand is provided by the Crusilite electric furnace element made by the Morgan Crucible Company Limited.

Crusilite can operate in temperature ranges extending up to 1,500° C. Furnaces covering the higher temperatures in this range—for example, for glass, china, pottery, porcelain, drop-stampings and forgings—can only meet the temperature and corrosion conditions by the use of silicon carbide elements. The new element is a one-piece silicon carbide tube produced by a method that uses a spiral as the hot zone. The company claim that the unit is not so susceptible to failure as other elements produced by different processes and that it ages at a much lower rate. The elements and two demonstration furnaces (Fig. 6) will be displayed.

Clarke, Chapman and Company Limited provide an example of a firm displaying its equipment on its own stand. Models of marine auxiliaries are the main feature. There will be 11 models, including an anchor and mooring windlass, a warping capstan, a totally-enclosed splash-lubricated cargo winch, and a steam automatic rendering winch. A non-marine exhibit will be a one-eighth scale model of an electrically driven double-drum winder for pit cages in coal mines (Fig. 7).

Some firms are exhibiting in more than one section of the main exhibition. Metropolitan-Vickers Electrical Company Limited, for example, will be seen both in the British Industries Pavilion and in the Hall of Science. The exhibits in the former will be included in the British Electrical and Allied Industries joint display and will consist mainly of models—locomotives, a turbo-generator, and a transmission and distribution model.

The company's exhibits in the Hall of Science will be a mass spectrometer, which is used for the analysis of organic and inorganic gases and vapours, and a high-frequency plastics welder for use in the garment trade. The type MS2 mass spectrometer, Fig. 8, essentially performs three functions. It produces ions from the sample being studied, it sorts them according to their mass-charge ratio by suitably disposed electric and magnetic fields, and it measures and records the relative amount of ions in each mass number. A sectioned model of a mass spectrometer tube will also be shown.

These few examples picked at random from the many exhibits of British firms show a variety in structure and size that is typical of the whole exhibition. To quote Sir John Balfour again: "The exhibition will be a vast clearing house for the exchange of ideas and advancement of knowledge in the most varied fields of human endeavour. Architects and designers; artists and scientists; industrialists, businessmen, and technicians of every sort will find in the exhibition something of value to study."

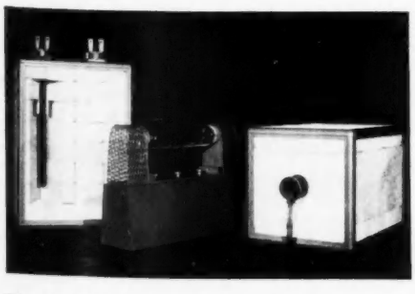


Fig. 6 These demonstration furnaces will be shown in the British industries pavilion. They will operate up to 1,500° C.

Atomic Review

Now and Then

Two non-ferrous metals were receiving much attention in Chicago during the early 1940's—uranium and plutonium. At the beginning of the period the properties of plutonium were merely guessed at; but it soon showed itself to be no ordinary material. As its highly toxic and radioactive qualities became appreciated, rigid security precautions became the order within, as well as without, the laboratories engaged on fission research. Now, 15 years after the first unequivocal separation of the material, the broad outline of the story is known—and further details emerge from time to time.

One such set of details is contained in a paper "The Microscale Preparation and Micrometallurgy of Plutonium Metal" by S. Fried, E. F. Westrum, H. L. Baumbach, and P. L. Kirk. The subject has only recently been declassified by the United States Atomic Energy Commission and concerns work done at the University of Chicago's Metallurgical Laboratory—operated by the University for the United States War Department. Now and then, it is worth looking back over a subject in a state of flux to gauge the amount of development; so extracts from this paper are printed below. By way of comparison, notes on present techniques of separating plutonium and uranium follow. Further notes describe other contemporary aspects of nuclear materials.

Early Plutonium Experiments

In May, 1940, minute amounts of the artificial element neptunium were detected in uranium bombarded in the University of California cyclotron. This element was expected to be the intermediary step to the production of plutonium. Shortly afterwards, microscopic quantities of plutonium were produced. The infinitesimal samples could not be isolated but their chemistry could be roughly outlined by following them through chemical reactions by their radioactivity.

The authors of the above mentioned paper write: "A major chemical problem in the development of the release of nuclear energy was the preparation on the microgram scale of globules of plutonium metal suitable for investigation of its physical and chemical properties. Micrometallurgy on this scale was unprecedented; an entirely original approach was necessary. The uncertainty inherent in the prediction of the physical and chemical properties of a new element (in a series the very nature of which was still under speculation), the exceedingly small amounts of plutonium available, the doubt as to the identity and composition of compounds to be reduced, and the extreme health hazard of traces of the finely divided solids aggravated the problem. The complex allotrophy of plutonium, which was not then suspected, also contributed to the difficulty of these investigations.

"Preliminary experiments were made on "stand-in" compounds, which it was hoped would simulate the behaviour of plutonium compounds in reduction to the element. The objective was reduction on the microgram scale with high yields of metal in a single globule. A variety of methods was tested, including reduction with atomic hydrogen, electrolytic reduction in aqueous and fused-salt systems, and thermal reduction of halides with alkali and alkaline earth metals; only the last mentioned proved successful and is described here.

"On the basis of the limited data available, uranium compounds were selected as probably representative of the chemical reactivity and physical properties of the analogous plutonium compounds. Uranium tetrafluoride was chosen because of its stability, nonhygroscopicity, and comparative nonvolatility. It was anticipated that plutonium tetrafluoride would have a similar set of desirable properties.

"The first attempted reductions were performed by distilling alkali metals on to uranium compounds placed in the tip of glass micro-cones *in vacuo* and removing excess alkali metal by heating the mixture gently with a flame. Further inconclusive attempts to reduce a few micrograms of uranium tetrafluoride and plutonium tetrafluoride to metal by treating it with sodium in evacuated glass capillaries emphasised the need for practical criteria for identification of metal on the micro scale. Methods involving the metallic characteristics of malleability, high density, lustre, and especially the formation of a hydride, were adapted to micro scale work.

"The first unequivocal production of plutonium metal was made in November, 1943. About 35 micrograms of plutonium tetrafluoride were transferred to a small thoria crucible on the tip of a sharp needle. About ten times the stoichiometric amount of barium metal freshly cut under xylene was placed in a larger crucible, the small crucible was inserted on top of the reductant, the outer crucible cap inserted, and the entire crucible assembly placed in a microfurnace and fired at 1,400° C in a high vacuum. A number of 3 microgram plutonium-metal globules were formed. The metal had a silvery lustre, a density of about 16 gm/cm³, and rapidly absorbed hydrogen at about 210° C to form a black powder subsequently identified as PuH_3."

Later the process was scaled up to the milligram scale. Very soon after that, the first reductions of plutonium were made at the Los Alamos Scientific Laboratory in New Mexico, and in April, 1944, plutonium was first produced on a gram scale there. Argonne National Laboratory, near Lemont, Illinois, succeeded the

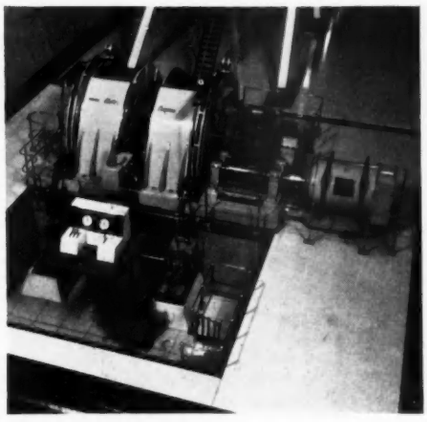


Fig. 7 A scale model of an electrically driven double-drum pit winding gear is one of the models on the stand of Clarke, Chapman and Company Limited.

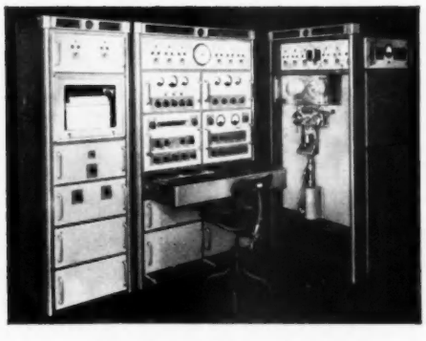


Fig. 8 In the Hall of Science, this modern mass spectrograph will be one of the British contributions.

Continuing Atomic Review

Metallurgical Laboratory, Chicago, after the Second World War.

The accomplishments in micrometallurgy at the laboratory soon led to the determination of some of the properties of the new metal. Plutonium exhibits some striking peculiarities: it occurs in no fewer than six different crystal forms, two of which shrink on heating; its density may vary by as much as 24 per cent, depending on the crystal structure; its own radioactivity produces sufficient heat to melt a piece of the element thermally isolated from its surroundings—it has a low melting point, like aluminium.

The Dounreay uel Cycle

In our issue of 7 June 1957, on page 725, we made some reference to the construction of the Dounreay Materials Testing Reactor (DMTR), and published a diagram showing enriched and natural uranium fuel processing cycles, in which plutonium and fission products are extracted, for the materials testing and the fast reactors. A simplified Dounreay fuel cycle is shown in Fig. 1.

The fast reactor chemical separation plant receives irradiated fuel elements embedded in lead inside a stainless-steel container which is conveyed from the reactor to the plant in a shielded "coffin." After removal from their stainless-steel containers, the elements are mechanically stripped of their cans leaving the bare uranium metal containing plutonium and fission products. The irradiated metal is then dissolved in nitric acid and passed through a four-cycle solvent-purification process which yields pure uranyl nitrate, plutonium nitrate and fission-product waste. The pure uranium solution is transferred to the metal fabrication plant, the plutonium to the Windscale Works and the fission products to the highly-active liquor-evaporation and storage plant.

The uranium and plutonium are recovered from the solvent by back-washing with nitric acid in a contactor. The backwash solution is re-conditioned and passed through a second and similar cycle further to remove fission products. The uranium is separated from the plutonium in a third solvent extraction cycle and the purified uranyl nitrate is transferred as required from storage tanks to the metal production plant. The plutonium is subjected to another purification cycle followed by concentration by evaporation and transfer to the Windscale Works for processing to metal.

The MTR chemical separation plant receives a complete reactor charge of irradiated fuel elements in a shielded coffin from the reactor. The elements are dropped into a pond of water and the sides milled off to separate the individual plates. The plates are coiled and charged singly into a dissolver. In this manner the amount of fissile material fed to the plant is carefully controlled, thus ensuring that it is maintained at a safe value.

After charging the dissolver, the fuel elements are dissolved in nitric acid to give a solution containing aluminium, uranium, a small quantity of plutonium, and fission products. This solution is passed through a solvent extraction process which removes the aluminium and fission products. The resulting uranium solution is purified further by another solvent extraction cycle which removes the plutonium and any residual fission products.

The pure uranyl nitrate solution is then transferred to the metal-production plant. The aluminium and fission product solutions from the first and second purification cycles are sent to the highly-active liquor evaporation and storage plant.

Uranium Metal Production

Part of the chemical and metallurgical processes conducted by the Dounreay chemical processing group enables uranium to be purified and re-cycled through the reactors. Uranium from both the materials testing reactor and the fast reactor are processed separately. In the normal re-cycling system, uranium solution is received from either the DMTR or the FR chemical separation plants, converted to metal and passed forward either to the DMTR or the FR fuel-element plants for fabrication into fuel elements.

In the course of the various processes quantities of impure or unworkable uranium arise. These require special treatment for purification and conversion to pure metal. The purification is carried out in a recoveries section of the metal-production building at Dounreay to give a uranium solution. This solution is then converted to metal, after blending with the solution received from the chemical separation plants. The sequence of operations is shown diagrammatically in the upper half of Fig. 2.

Aqueous solutions of uranium are transferred from the fuel-element chemical separation building to the metal-production building, where they are concentrated by evaporation and put in storage tanks. The addition of high or low enriched uranium is made as necessary to produce a blend, at the aqueous liquor concentrate stage, of the required enrichment and purity. This material is then passed through a series of processes involving precipitation, drying and conversion to a solid compound which is then made to react with a metal to give a uranium billet and a slag. The as-cast metal billet is then passed to the fuel-element fabrication processes section.

During the process of metal production some uranium is retained in side streams and, in addition, material for recovery arises from the fuel element production processes. These materials are processed in a recovery section through the stages of dissolution, filtration and solvent extraction to give an aqueous solution of uranium pure enough to be fed back to the metal-production section after blending with the main bulk of solution coming forward from the fuel-element chemical separation plants. This recovery process is shown diagrammatically in the lower portion of Fig. 2.

Equilibria of Nuclear Engineering Alloys

The equilibrium diagrams of three metallic systems of interest in nuclear engineering are discussed in papers published in the December, 1957, issue of the *Journal of the Institute of Metals*. They are the plutonium-thorium, the thorium-cerium, and the plutonium-iron systems. The papers are to be discussed during the Institute's Spring Meeting, in London, on May 1.

The plutonium-thorium system has been studied by Dr. D. M. Poole, Dr. G. K. William-

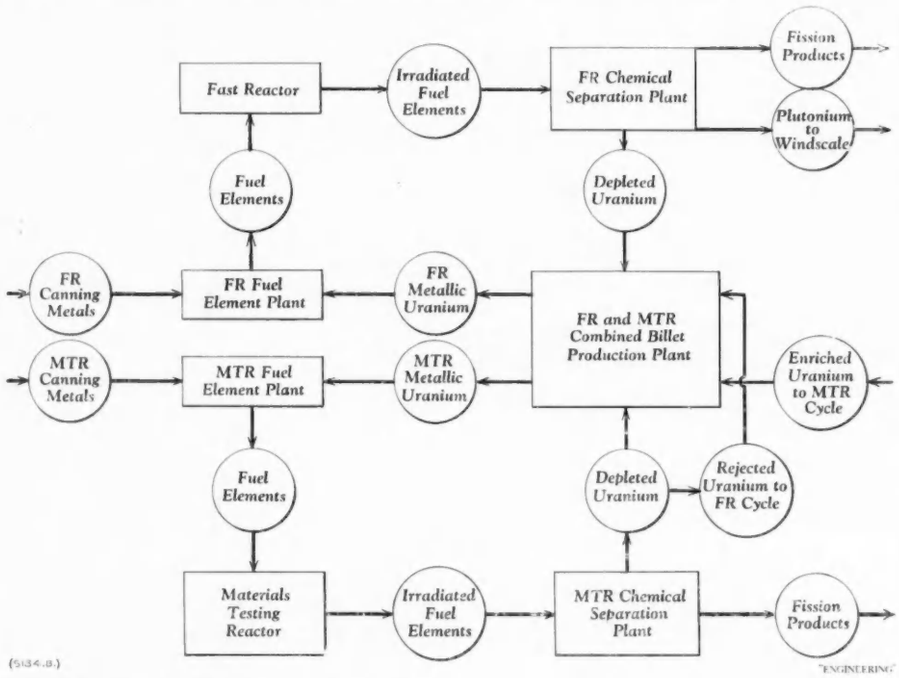


Fig. 1 (above) The Dounreay fuel cycle showing the working of the Fast Reactor and Materials Testing Reactor and their separation plants.

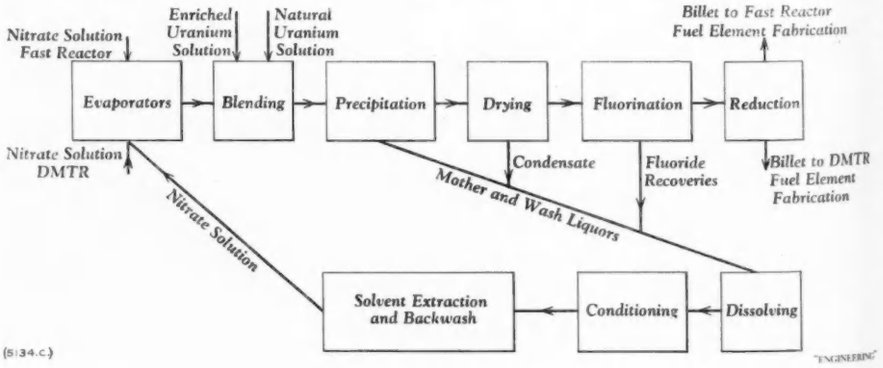


Fig. 2 (right) Diagrammatic representation of the uranium purification plant (upper portion of illustration) and of the recovery section (lower portion of illustration).

son and Mr. J. A. C. Marples, of the Metallurgy Division of the Atomic Energy Research Establishment, Harwell, by means of X-ray, metallographic, thermal-analysis and dilatometric methods. The authors have found that plutonium dissolves extensively in α-thorium, the maximum solubility being 48·5 atomic per cent at 615° C. At about 32 atomic per cent thorium, a compound, ζ, occurs which is probably orthorhombic; this compound forms peritectically at 615° C, from the α-thorium + liquid field which extends over a large portion of the diagram. This large solubility of plutonium in α-thorium, it is thought, is possibly associated with a considerable increase in the apparent atomic radius of the plutonium atom.

The thorium-cerium system has been studied by means of X-ray and micrographic methods by Mr. R. T. Weiner, Dr. W. E. Freeth and Professor G. V. Raynor, of the Department of Physical Metallurgy in the University of Birmingham. The system shows complete solid solution over the whole composition range at room temperature. The alloys are face-centred cubic, and an anomalous decrease in the lattice spacing of the thorium-rich alloys with increasing cerium content, is observed. The solidus, which has been found to be a smooth unbroken curve, has so far been determined up to a temperature of 1,550° C.

The authors of the paper on the plutonium-iron system are Mr. P. G. Mardon, Mr. H. R. Haines, Mr. J. H. Pearce and Dr. M. B. Waldron, of the Atomic Energy Research Establishment, Harwell. They state that their results verify the existence of (*a*) the compounds Pu_6Fe and $PuFe_2$, (*b*) a low-melting point eutectic between δ-plutonium and Pu_6Fe, and (*c*) a high-melting point eutectic between $PuFe_2$ and γ-iron. An unusual type of eutectoid reaction has been observed in plutonium-rich alloys in a region not shown in detail on a diagram published by the Russian metallurgist, S. T. Konobeevsky, during the course of the present work.

Uranium Recovery by Ion Exchange

Undoubtedly the largest single application of the ion-exchange process outside the field of water treatment is in the recovery of uranium from the leach liquors resulting from the acid attack on uranium ores. Such is the opinion of Mr. Robert Clark, who dealt with the subject in some detail during the course of his presidential address to the Society of Engineers in London on February 3.

Continuing his address, Mr. Clark stated that the large supplies of uranium required for atomic-energy applications could not be produced from the very few high-grade sources known in the world, and, in the years immediately following the Second World War, an extensive search had been made for other sources of supply. Large deposits of low-grade ores, in fact, had been discovered in South Africa, the United States, Canada, Australia, Rhodesia, France, Spain and Sweden. The leach liquors obtained from the treatment of these ores contained very small quantities of uranium in the presence of much larger concentrations of common metals such as iron, aluminium and zinc.

The treatment of these liquors by chemical methods, for the recovery of the uranium, was difficult and extremely expensive. Fortunately, it had been discovered in 1948 that a sulphate solution of uranium formed a complex anion which could be absorbed by a strong base anion-exchange resin, whereas common metals did not form such anions and passed through the resin unabsorbed.

A series process in which the acid leach liquors were passed through two or more columns of resins had been put into operation on an industrial scale in 1950. The uranium was absorbed by the resin and the other metals passed through to waste. When the resin was saturated the column was taken out of the line and a spare column brought into service, so that the flow of liquor was continuous. The uranium was removed from the resin by passing though it a solution containing chloride or nitrate ions which broke down the uranium complex and removed it from the resin bed.

The whole process was fully automatic and, for example, two sets, each of four ion-exchange columns at Port Pirie, South Australia, ran fully automatically with no attention at all, except for the regular taking of samples for testing.

The unit was capable of producing up to a ton of uranium oxide a day and several hundreds of these units had been installed at mines all over the world.

It was true to say that, but for the discovery of this ion-exchange process, the whole advance of the atomic energy programme would have been held back seriously.

Notes and News

Anglo-American Exchanges on Atomic Ships

There is a growing feeling on both sides of the Atlantic that wasteful duplication of research in the development of nuclear ships could be avoided by closer co-operation in the interests of common progress and the economic welfare of both countries.

Exchange of information would appear to have been confined to submarines and is facilitated by frequent reciprocal visits to Britain and America by scientists, Government officials and senior officers. Admiral Rickover's recent visit to Britain was an example. Members of the United States Atomic Energy Commission and the British Atomic Energy Authority are constantly in touch on Naval nuclear developments. However, no permanent working group exists in Washington. Although there is no reason why some of the Naval reactors should not be used commercially, the extent of exchange of information on civil ships, if any, is not known.

Reviewed in this light, the recent statement of Mr. Galbraith, Civil Lord of the Admiralty, in the House of Commons, that there is " the closest possible co-operation " between Britain and America in work on nuclear warships, encourages the hope that both countries will strive for still closer co-operation over the whole field of nuclear propelled ships.

N.S. Savannah: Nuclear Powered Merchant Ship

Information has been released concerning the United States Atomic Energy Commission and Maritime Administration programme for the operation of what is stated to be the world's first nuclear-powered merchant ship, the N.S. Savannah.

The keel of this ship will be laid in May 1958 by the New York Shipbuilding Corporation, Camden, New Jersey, and should be completed by 1960. It is proposed that it should undergo initial trials and tests over a period of six months to a year, to be followed by a period of operation in modified commercial service before going into passenger-cargo service.

The Atomic Energy Commission and Maritime Administration are now negotiating with American shipping firms with a view to granting an operating contract by 1 June 1958. A highly trained and competent crew of about 25 officers and 84 men—essentially the same as for a conventional ship of the same size—will be required, and a special training programme has been drawn up by the A.E.C.—Maritime Administration. Licensed engineering officers will be required to report for training on or about 1 September 1958 and the remainder of the crew, as required, after that date.

Nuclear Tanker in United States

The United States Atomic Energy Commission and the Maritime Administration, United States Department of Commerce, announced recently the award of contracts for preliminary engineering and design studies for the conversion to nuclear power of a tanker now under construction. The contracts are with George G. Sharp, Incorporated, as the ship design agent, and the General Electric Company as the reactor designer. The companies will work concurrently and together to provide the necessary contract plans and specifications for a reactor and for conversion of the ship. The studies will outline the engineering problems and will provide a basis for cost estimates for the conversion of the ship to nuclear propulsion. The studies will be completed in about three months. The tanker, under construction at the Ingalls Shipbuilding Corporation in Pascagoula, Mississippi, is a 22,500 deadweight ton prototype, designed for a normal speed of 20 knots at 20,000 s.h.p

German Atomic Powered Freighter

There is interesting news from Germany that an atomic powered freighter built by them will make its maiden voyage early in 1961.

Co-operation in this field of nuclear research is difficult to achieve, but the example set by Herr Thomas Entz, the Rendsburg shipowner, is noteworthy. He has allowed a freighter which was on order from the Kiel Howaldt shipyards to be used as a prototype nuclear propelled vessel. The construction has been changed to provide a reinforced structure to carry a reactor, and it has heavy shielding. Herr Entz is one of those who believe in the future of nuclear power. Germany also intends to develop its own power reactor for this purpose and with this objective the four coastal states of Hamburg, Bremen, Lower Saxony and Schleswig-Holstein have set up a committee to study nuclear power reactors for merchant vessels.

F.B.I. Conference

The Federation of British Industries has convened what is claimed to be the first British conference of a non-technical nature, for the specific purpose of dealing with the industrial implication of nuclear development for top management. This is being held at Eastbourne from 9 to 11 April, followed by a visit to the United Kingdom Atomic Energy Research Establishment at Harwell on 12 April. Attendance has been limited to 100 members of director status, including 25 industrialists from overseas. Leading experts from the United Kingdom Atomic Energy Authority and nuclear power firms are presenting papers on various aspects of nuclear energy development, and these are followed by discussion. We intend to publish a report of the proceedings in a forthcoming Atomic Review.

M.I.T. Course in Uses of Radioisotopes

The Massachusetts Institute of Technology, Cambridge, U.S.A., is holding a special summer school on " Principles of Radioisotope Utilisation " from 14 to 25 July 1958. The course is being organised by Dr. Gordon L. Brownell, Assistant Professor of Nuclear Engineering at M.I.T., and members of staff from various departments of M.I.T. will take part.

The course is intended to provide a sound understanding of the basic principles of the use of radioisotopes and radiation in engineering, basic research, and the medical sciences. Topics to be covered include atomic and nuclear physics, dosimetry, radiochemistry, detection of radiation, radiation effects, and theory of tracer experiments. Practical application of radioisotopes will also be demonstrated and a special feature of the course will be the use of the M.I.T. research reactor for experimental studies. The tuition fee is 250 dol.

Atomic Energy Authority's 100 Bedrooms

Mr. Denzil Freeth, the Conservative member for Basingstoke, asked the Prime Minister to explain why the United Kingdom Atomic Energy Authority had found it necessary to purchase the Durley Hall Hotel at Bournemouth, an establishment with about a hundred bedrooms virtually on the sea front. In reply, Mr. R. A. Butler, the Lord Privy Seal, said that the hotel had been bought as a hostel for the accommodation of staff who will be employed at the Winfrith Heath Establishment. It was a matter of day-to-day administration with which the Prime Minister did not regard it as his duty to intervene.

The Human Element

Riposte for the Critics

Lord Cohen, chairman of the Council on Prices, Productivity and Incomes, has replied to the critics of the Council's first report, published on 21 February. He explained that the Council took the view that Britain's greatest need was that the rise in prices should be stopped. The spiral of rising prices-rising wages had to be broken if the country was to remain competitive in world markets or, to use the Prime Minister's own words, avoid becoming " an island of inflation in a sea of deflation."

The Council met in the shadow of a major sterling crisis. The Government's safeguarding measures had evidently convinced foreign holders of sterling that they were wrong to expect devaluation. But if prices started to rise again their conviction will be weakened and a new crisis will arise for the currency. " Rising prices," Lord Cohen said, " are a thoroughly bad thing. We should not acquiesce in them. We need to muster some national resolution in this issue, and to find ways of stopping the inflation." Only when the rise in prices was " clearly and certainly " seen to have stopped would it be safe for economic expansion to begin again.

Having established quite clearly the objectives of the Council, Lord Cohen explained that there were certain inevitable results of a disinflationary policy. One was to make less work for people and therefore some short-time and unemployment. Another, also due to reduced demand for goods and services, was to make profits harder to earn: " Companies found it more difficult to pass on increases in costs, competition was keener, and profits were squeezed." Yet there appeared to be no doubt whatever in Lord Cohen's mind that this painful process of breaking the wage-price spiral had to be adopted.

Strike on the Ruhr

Lord Cohen's troubles are small in comparison with those being experienced by the German and the French Governments. The reason, doubtless, is that inflationary pressures are even greater in those countries than they are in Britain. Meeting recently at Gelsenkirchen, the German steelworkers' union called on the 184,300 steelworkers in the Ruhr to strike on 9 April.

The strike is to back a claim for wage increases. The union have revoked earlier concessions and re-instated their original demand for a 10 per cent increase. The employers have offered 3·7 per cent and the Minister of Labour for North Rhine-Westphalia has suggested 5 per cent.

There is no doubt some substantial rise will be given, probably on the basis of a compromise. Steelmakers plead that declining orders in the industry, and a growing keenness of competition in export markets is making it impossible for them to absorb so high an increase as has been claimed. The unions feel, equally strongly, that their members' wages have lagged too far behind those of other countries for too long, and claim that the employers' resistance is political in character. In Government quarters it has been suggested that the decision to strike is linked in some way to the protest action planned by the trade unions against the adoption of atomic weapons by the German forces. Whatever the cause there is trouble, and by far the most serious in Germany so far since the war.

En Garde

The 24-hour strike of public transport employees in France just before the holiday was too well supported to be misinterpreted. It was a warning that workers will insist on getting a bigger share of the national cake. The fact that all three of the big unions were supporting the strike—most unusual in view of the basic differences between them—reflects the very widespread resentment felt against the French Government for what is said to be their failure to pass on to the workers the benefits of increased efficiency and productivity.

France now stands where we stood some little time ago and, in some ways, still do to-day. The spiral of wages and prices has to be broken if the country is to withstand the tremendous pressures on her currency. Exports have failed to expand and practically the whole of the present-day prosperity is inflationary in character. Only the ability of the French to live well and sustain their industry out of their own resources has enabled them to carry on like this for so long. Nonetheless, there is a drain on French reserves of foreign currency and it cannot go on much longer without borrowing more from abroad or considerably reducing home consumption.

Catching them Young

The Leonardo da Vinci lectures were begun by the Institution of Mechanical Engineers to stimulate the interest of senior schoolboys in mechanical engineering as a career and as an intellectual discipline. " Rockets and Guided Flight " was the subject of the third annual Leonardo da Vinci lecture, to which the Institution of Mechanical Engineers last week invited some 600 public and grammar-school boys—and, for the first time, girls, because, as Sir Ewart Smith explained in an introductory talk, the Institution expect women to play an increasingly important part in applied science.

The " lecture " comprised, in fact, three separate talks followed by a short questions session; and there was also an exhibition of rocket and missile components, including a Skylark high-altitude research rocket and a sectioned experimental vehicle. Dr. G. W. H. Gardner, director of the Royal Aircraft Establishment, surveyed the evolution of the missiles, the main features of an experimental rocket, the problems of ballistic flight—launching and re-entry—and finally satellites and the possibilities of space travel which, he thinks, is still technically some way from accomplishment. Professor A. D. Baxter, chief executive of the Rocket Division of the de Havilland Engine Company, Limited, discussed rocket motors and fuels, and obtained the usual delighted reactions to practical demonstrations of propulsion by reaction, with a toy balloon, and of the spectacular properties of liquid oxidants. Finally, Mr. L. H. Bedford, chief engineer of the Guided Weapon Division of the English Electric Company, Limited, provided a masterly and vivacious treatment of guidance—outlining the principles of beam-riding, command guidance, homing, and inertial guidance, and concluding with a film of weapon trials.

As Others See Them

The Institute of Directors has issued a pamphlet with a foreword by Lord Chandos called *Understanding Labour Relations*. It is a useful and stimulating publication, although in some ways it may be just a bit too clever. It pursues the general line of thought that the unions are moving towards political independence and that as this occurs they will become increasingly interested in management problems. There are a few signs that this trend may exist but they are very slight as yet. Union solidarity and working-class solidarity are not the same thing, but they fit like a glove on the hand and they find a convenient expression in the Labour Party which is the working man's party against the highly organised " boss class "—such is the view of most working men and women.

With the idea that labour relations should be improved by the greater use of joint consultation, sound recruitment and better training schemes, there will be complete agreement among all enlightened employers. To some extent this growing need for better organised relations springs from the idea mentioned above: the unions are going to be increasingly interested in management matters and also from the thought that a greater interest in management affairs means less centralised control in the unions. This again may be slightly wishful thinking. The fact is that good labour relations can be justified on their own grounds without any political implications.

A Stitch in Time

The Government's policy of allowing the cotton textile industry to find its own level without any special form of tariff protection is working out in an increasingly rapid rate of decline. Mills are closing fast in Lancashire and recently a company was formed by two of the trade associations to carry on a systematic closing-down scheme. Some 200,000 spinning and weaving employees have now presented the employers with a comprehensive redundancy plan.

There have been so far a large number of individual redundancy schemes in cotton, but this is the first to be presented on an industry-wide basis. Its object is to provide compensation for loss of job with some regard to age and seniority. What this means exactly to the employers is not yet clear but the idea is worth consideration. The turnover in the industry is high and a very large proportion of the workers are women. The rate of turnover is reckoned to be about 20 per cent which means a complete turnover every five years and therefore a limited liability for age and seniority payment for the industry as a whole.

Whatever happens in the cotton industry will nevertheless act as some kind of a precedent elsewhere. In this case the problem is not one of cyclical unemployment (as it is apt to be in motor vehicles for instance) but of secular contraction with no prospect of subsequent expansion. Cotton would, however, give some experience of a wide compensation plan for loss of work which might be useful for others.

Swallowing the Medicine

With not a little reluctance, the leaders of the National Union of Mineworkers agreed last week to recommend acceptance of the idea to a national coalfield conference that the National Coal Board's economy programme is inevitable. Nothing is to be done about the idea of restriction of oil imports. This will not even go to the T.U.C. and control of opencast working is to be brought about only by limiting new contracts.

Delegates to the conference have been faced with the need to agree to the curtailment of Saturday working and a cessation of recruitment. They will be all the more reluctant to accept the N.C.B.'s prescription indefinitely since there is a wage claim about to go to arbitration and the Miners' Charter is still dear to many influential delegates. This is indeed the first time since the war that both the Coal Board and the miners have had to recognise that increased benefits for the miners cannot be passed on to the consumer. For the first time the Board and the N.U.M. must either fight it out between them or agree on the economic measures to put things right. There is no third party at present who can pay or will pay the bill for amicable relations within the industry. The fact is probably equally unpleasant to both sides.

Companies in the News

Ford in Top Gear Once Again

Announcing the very satisfactory results obtained by the Ford Motor Company in 1957, their chairman, Sir Patrick Hennessy, commented that the recovery in earnings to the peak level of three years ago might well suggest steady and uneventful progress but, he said, "such was far from being the case." Turnover, at £166 million, was higher than ever before and trading income, at £19·4 million, was £9 million higher than last year. In fact, if charges to depreciation, obsolescence and pension funds are added, the gross trading profit was nearly £12 million greater than in 1956. But the full story behind the progress is a most interesting commentary on the tremendous potential of motor vehicle manufacturing.

There were two distinct phases during the year, said the chairman. During the first, which lasted until March, car business remained at a seriously low level; during the second, from April to December, demand recovered rapidly to unexpectedly high levels. It is quite clear from Sir Patrick's speech that the Government's policy of high interest rates and credit restrictions had little if any impact on the demand for cars last year. It was petrol rationing following the Suez crisis which arrested normal demand in Britain and most European countries. As soon as it had become evident that the flow of oil would shortly be resumed, almost exactly a year ago, "within the space of a few weeks anxieties of short-time working gave place to the problem of getting maximum production."

Sir Patrick Hennessy attacked the Government's policy of high taxation for motor vehicles. Unless the industry gets purchase tax relief he does not think they could compete successfully in a European free trade area. Ford continued to invest heavily in modernisation. Their new Thames foundry cost £1 million, and is said to be the most advanced in Europe. Total expenditure on fixed assets during the year amounted to £19½ million and there were outstanding contracts at the end of the year of £13½ million. Production of vehicles at the end of the year averaged 1,552 per working day. When the current expansion programme, which includes the opening of a new press shop later this year and a new assembly building early in 1959, Ford will be in a very strong position.

Machine Tool Problems

It was evident from what was said at the recent annual dinner of the Machine Tool Trade Association that the industry is experiencing some anxious moments. It is in this psychological state when unfavourable factors tend to be exaggerated. Nonetheless, it is a fact that the industry's order book at the end of 1957 totalled £78·7 million, compared with £105 million reached in mid-1956, representing only about nine months' output at current rates. This fall is world-wide, being heaviest in the United States and least in Germany (orders booked by German makers were about 10 per cent less than in 1956). It has been especially marked for standard machines, though so far the heavy and more complex machines have remained in relatively short supply.

Not all makers are despondent about the future, and some of the more optimistic are makers of standard machines. Generally speaking, the better off are those who have been prominent in sales development and who have built up a good world-wide reputation. The startling success of the Colchester Lathe Company in the United States market is a tribute to the quality of their machines and, above all, to the energy and drive of their management. Another company who face the future with confidence is the Asquith Machine Tool Corporation. Mr. Robert Asquith told shareholders recently that as far as he could see, "1958 should be another successful year"; he and his colleagues are sure that they will get their "full share of any business which is available."

There is no doubt that orders for machine tools are being placed much more hesitantly than even a few months ago. In some quarters, however, there appears to be signs of recovery in demand. Mr. Asquith's comment that "competition is growing keener all the time" is widely applicable. But the industry is now able to compete on delivery with any in the world, and can compete in price with most. These are conditions in which vigorous and imaginative selling yield high dividends.

Locomotives Feel the Draught

There are few companies in the world for whom the building of locomotives is an expanding source of income. For most of the leading makers the reverse is true and there is a general scurry to find other products. Even the vast re-equipment programme of British Railways has failed to turn the tide for builders in this country.

The same is true in the United States. ALCO Products Inc., formerly the American Locomotive Company, are trying hard to insulate themselves from the depressed state of demand for locomotives by developing new products. Their president, Perry T. Egbert, strongly emphasised to shareholders in his report on 1957 that products other than locomotives had been developed with all possible speed and accounted for 68 per cent of ALCO's total "regular business" (excluding an armament contract for tanks). He drew their attention to the fact that their company's long-term potential for regular products other than locomotives "lies in some of the strongest growth markets, such as chemical, petroleum, electric utilities and atomic energy." Research and development activities grew in 1957 including the nuclear as well as metallurgical and thermal fields.

The reason for the declining demand in locomotives is probably mainly one of saturation in industrialised countries and a decrease in the relative importance of the railways in newly developed countries. Locomotives "last for ever" and until a new type of motive power comes along replacement demand is practically nil, in the United States as well as in Britain. In the years of the diesel locomotive replacement programmes, from 1949 to 1953, ALCO's output of locomotives averaged well over 100 million dol. Last year it fell to 34·8 million from 48·7 million in 1956 and is likely to decline further.

Ports and Waterways

The activities and prospects of the Manchester Ship Canal Company were the subject of a most interesting and informative report by the chairman, Sir Leslie Roberts. The reduction in total income resulted mainly from the fall in the volume of sea-borne traffic handled by the Port of Manchester. The operation of the canals – both the Ship Canal and the Bridgewater Canal —yielded higher profits than the previous year, despite a slight fall in the volume of traffic handled and steeply rising dredging costs.

Sir Leslie Roberts emphasised the urgent need to modernise the port facilities, in which they have an interest both in Manchester and Liverpool, a problem which, he said, concerned all the ports of the country and was "greatly exercising the minds of those responsible for their direction and management." The company have accumulated over £3 million in a provision account and will presumably undertake a modernisation programme over the next few years. Sir Leslie anticipates that the pattern of the port's oil traffic will change and that the oil traffic of the port of Manchester will be affected—"in some respects adversely, and it may well be, in some respects favourably." He had in mind the construction of deep water oil berths in the Mersey off Tranmere Beach to accommodate large tankers, the construction of pipelines between the Shell company's Stanlow refinery and their chemical refinery at Partington which, he said, "may be developed into one of the biggest chemical plants in Europe in the market both at home and abroad."

The problem of the Manchester Ship Canal Company is essentially one of adaptation to such changing conditions. The real difficulty is to determine "what form the change will take." It is also a sales problem—"to show importers and exporters the facilities which we have to offer."

Chemicals Expand Further

The chemical industry appears to have maintained the profitability of its operations better than most other industries during 1957. The annual report of Monsanto Chemicals and the announcement of the profits and dividend of Imperial Chemical Industries show that, unlike most engineering firms, manufacturers of chemicals have been able to operate to the full the new plant and equipment installed in recent years. Demand for most of their products has remained ahead of capacity, despite the latter's rapid expansion. Products have therefore been sold at good prices and profit margins have kept up very well.

I.C.I.'s group sales increased by £28 million, to £463 million; trading profits, before tax, increased by £5 million to £55·1 million and net profit by £2·4 million to £28·8 million. Monsanto's sales expanded by £1·7 million to £15·9 million and trading profits by £170,000. Their chairman, Sir Miles Thomas, paints a very cheerful picture of developments. The expansion of the group continues unabated in both the chemicals and plastics divisions. The construction of the new polyethylene plant at Fawley is proceeding smoothly and is expected to be completed this year. Commenting on the rapid expansion of the polyethylene market in the past two years, particularly in the United States, Sir Miles said that Monsanto were preparing, with the technical assistance of their parent American company, to enter this market "with a full range of fully competitive polyethylenes and to maintain an active development programme in this and associated polymer fields." Several further expansion projects are being considered for Fawley and also at the Ruabon plant in North Wales and at Newport. The intention, said Sir Miles, was to strengthen further the company's position in rubber chemicals, oil additives, fine and heavy chemicals and styrene-based plastics. The gains in efficiency expected to result from further expansion are expected to enable the company to strengthen their export business (export sales last year reached £6·4 million or 41 per cent of total sales) and to take "full advantage of any liberalisation of European trade."

This position of great strength of the leaders in the chemical industry is evidence enough that the widespread belief that the demand for chemicals and plastics was fully justified. It is a growth industry, and the development is unlikely to be affected by local fluctuations in industrial activity; it is mechanised to an extent which ensures it is affected less than most by rises in labour costs. Monsanto's report indicates that wages and salaries accounted for only 17½ per cent of total turnover, whereas in Ford's case (see other note on this page) it was 22·8 per cent. Materials, on the other hand, accounted for some two-thirds of turnover and both Monsanto and I.C.I. clearly benefited from the falling trend of raw material prices. But the secret of the chemical industry's success must surely be that it makes those things the world cannot do without, such as medicines, detergents, and new raw materials cheaper and better than the old. More than almost any other, its growth is based on technological advance.

Special Article

NEW SATELLITES IN ORBIT

By Kenneth W. Gatland

Vice-chairman of the British Interplanetary Society.

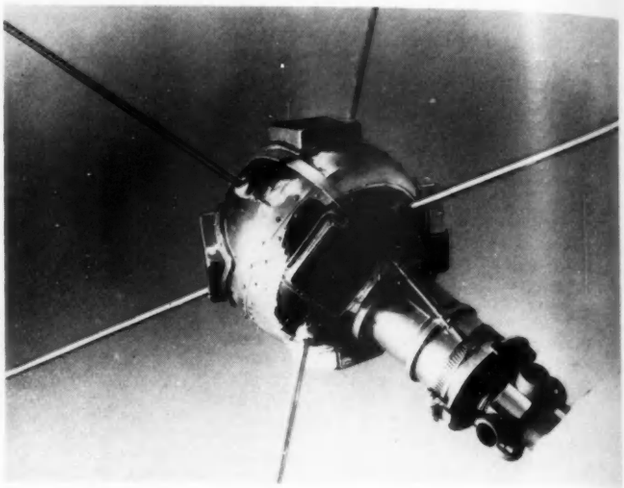


Fig. 1 Vanguard test-satellite, weighing 3¼ lb and 6·4 in in diameter, has six antennae and two radio transmitters. The six rectangular objects on the surface of the sphere are solar batteries powering one of the radio transmitters.

ALTHOUGH America's present satellites bear no comparison with Russia's Sputniks on a weight-for-weight basis, they do nevertheless represent a considerable advance in technique. The latest model, successfully launched by a Vanguard rocket on 17 March, is a 3¼ lb spherical satellite little bigger than a grapefruit. And yet, incorporated in this tiny orb is (Fig. 1) a radio-station in miniature with two separate transmitters and power supplies, one of them operating on energy from sunlight. In Table I are compared the five satellites that have so far been launched.

Unlike the Army's Jupiter-C/Explorer satellite, Vanguard—a Navy venture—has been developed from the outset as a purely scientific project for the International Geophysical Year and, despite widespread publicity given to early "failures," scientists of the Naval Research Laboratory responsible for the project have always insisted that these initial firings were experimental. Fig. 2 shows the Vanguard rocket on its launching platform at Cape Canaveral, Florida.

The first test-firing of the complete three-stage vehicle took place on 6 December last year when the rocket, failing to develop sufficient thrust, toppled sideways and exploded after lifting only a few feet. On 5 February, the second launching attempt also ended in failure after a successful flight of 57 seconds when a fault developed in the first-stage control system and the vehicle's subsequent erratic manoeuvres broke the rocket in half.

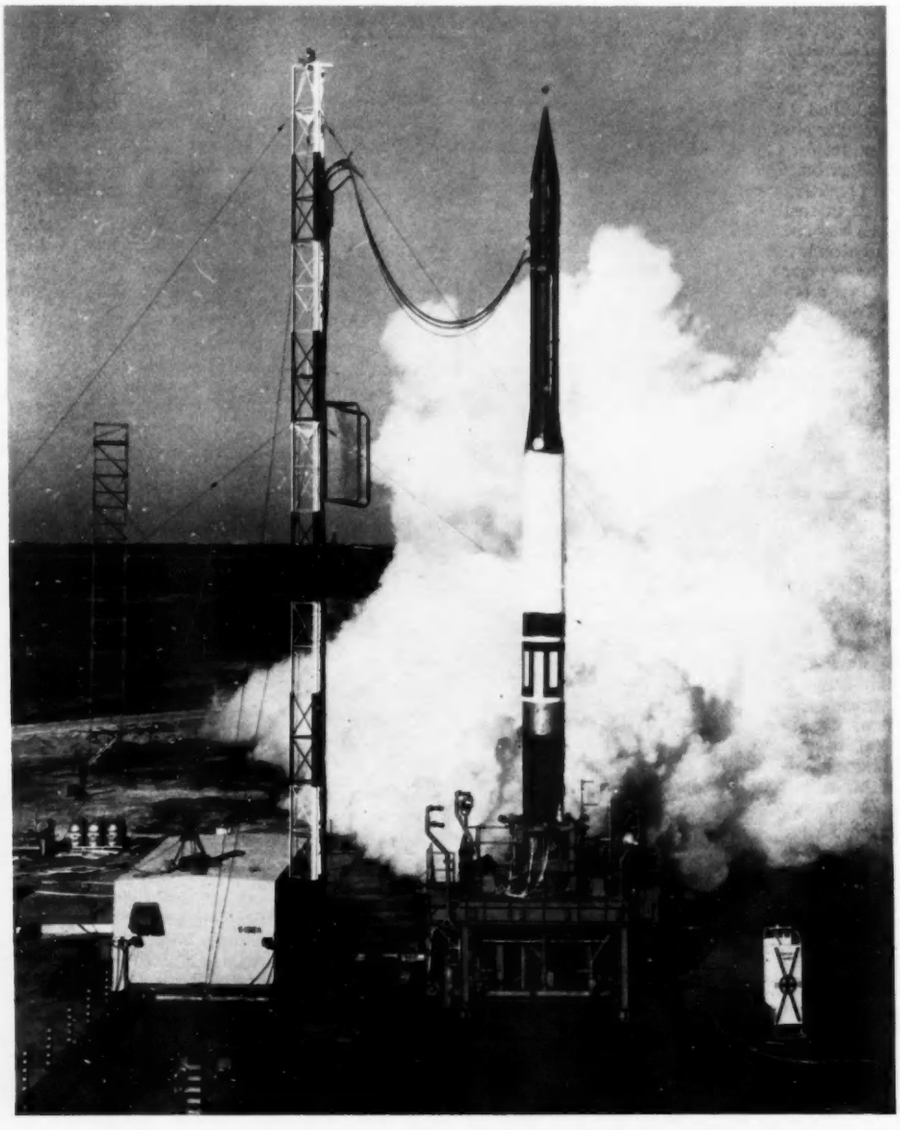


Fig. 2 The Vanguard rocket on the launching platform at Cape Canaveral, Florida.

TV-4, launched on 17 March, was the third rocket of the Vanguard test series, its primary purpose being to test the complete vehicle for the first time through all its stages. In particular, engineers sought conclusive checks of the separation of the second stage from stage 1, the ignition of the second stage at altitude, and the functioning of the rocket's controls under actual flight conditions. The incorporation of a small satellite in these early test-vehicles was almost a secondary consideration.

In physical appearance, the 72 ft Vanguard launching vehicle resembles an attenuated rifle bullet and cartridge, the larger diameter constituting the first stage. The rocket is finless, has integral tanks and a gross take-off weight (with propellents) of 22,600 lb.

Stage 1, which has been developed from the successful Viking high-altitude research rocket is essentially a guided booster which provides approximately 65 per cent of the energy to raise the remaining stages to orbital altitude and about 15 per cent of the required (horizontal) velocity. A comparison of Viking II and Vanguard characteristics is given in Table II.

After taking-off vertically from the launching base at Cape Canaveral, Florida, the Vanguard vehicle veers to the south-east along its programmed trajectory (Fig. 3), the first stage jettisoning at a height of 36 miles to fall eventually into the Atlantic some 250 miles away between Grand Bahama and Nassau, on New Providence. The angle of ascent at the time of separation is about 45° and the velocity about 3,700 m.p.h.

Stage 2, held on a curved flight-path by in-built controls, then accelerates to reach a maximum speed of about 9,000 m.p.h at 130 miles. Well before this point is reached, the ballistic nose-cone (which protects the satellite in the nose from aerodynamic heating) is discarded, the vehicle having by then outclimbed the denser part of the atmosphere.

Although its tanks are empty, Stage 2 remains attached to Stage 3 and the two vehicles coast together to orbital height (300 miles) with only slight deceleration—involving a drop in velocity of only 500 m.p.h. During this critical period of the ascent, directional stability is achieved by a programming device in the second stage, acting through an autopilot and helium gas-jet controls. In this way, stage 3 is aligned accurately on a path which is tangential to the earth's surface at the peak altitude. An axial

spin is imparted to the third stage before separation whereupon stage 2 is retarded by small solid rockets firing against the direction of motion and the final stage accelerates away to reach orbital velocity—approximately 18,000 m.p.h. This final burst of thrust stabilises the orbit. Finally a releasing device in the nose of the final stage—a spring mechanism operated by a timer—frees the satellite from the parent rocket.

Early measurements reveal that both the satellite and its 4 ft launching rocket (empty weight, 50 lb) are pursuing an elliptical orbit with a perigee (minimum distance) of about 400 miles and an apogee of 2,500 miles. This is by far the highest orbit to-date and is expected to give the tiny satellite a lifetime of 5 to 15 years before the very slight air drag at perigee begins to distort the orbit sufficiently for the orbiting body to fall back into the atmosphere.

The test-satellite, 6·4 in in diameter, consists of a spherical aluminium shell, two radio transmitters and their respective power supplies, and six 12 in dipole antennae for radiating the output of the transmitters.

There are basically three reasons for including this small satellite in what really amounts to a proving flight of the launching vehicle. First, it provides the radio signal by which the rate of acceleration of the third stage may be determined —a critical factor in the launching sequence. Second, it affords an opportunity to check the ejection mechanism for the fully instrumented 20 in satellites which are to follow. Third, it takes advantage of the possibility that an orbit might be obtained from a test-flight and the inclusion of radio transmitters provides an opportunity for Minitrack ground stations to gain valuable experience in satellite tracking.

Of the two transmitters carried, one is a 10 milliwatt system, powered by mercury batteries, which has an estimated life of about two weeks. The other, powered by six solar cells, has an output of about 5 milliwatts and is expected to last for a considerable period, perhaps as long as the transmitter remains in working order. The solar cells, fitted in rectangular housings on the outer surface of the sphere, comprise wafers of cadmium sulphide and are sufficiently sensitive to respond to the light of a powerful hand torch. They are protected from meteoric erosion by Vicor-glass panels.

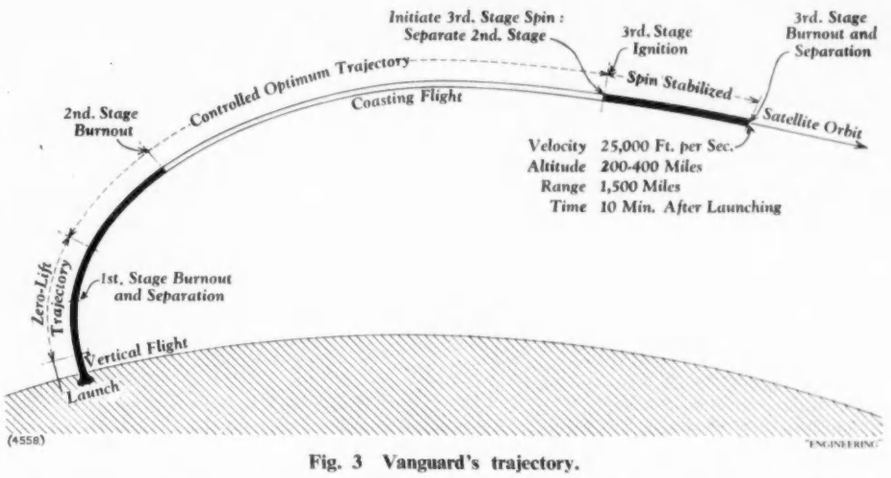


Fig. 3 Vanguard's trajectory.

Despite the fact that the satellite carries no instruments, an indication of temperature can be obtained from a change of frequency between the oscillators of the two radio transmitters. This is achieved by using frequency-controlling quartz crystals, the resonant frequencies of which vary approximately 100 cycles for every (Centigrade) degree of temperature. The crystal associated with the transmitter operating on solar energy is situated on the shell of the satellite and operates at 108·03 ± 4 Kc, while the crystal for the battery-powered transmitter (operating at 108·00 Mc ± 4 Kc) is located in the interior of the satellite, being well insulated from the outer shell. Recorded by ground stations, the changes in frequency provide an indication of temperature variations occurring on the surface of the satellite, especially at the time when the tiny sphere passes from sunlight into the earth's shadow and vice-versa, and of temperature conditions within the satellite.

The Martin Company of Baltimore, Maryland, is prime contractor for the Vanguard launching rocket. The satellite was designed and built by scientists at the Naval Research Laboratory, Washington, D.C., and the solar batteries were developed by the U.S. Army Signal Engineering Laboratories at Fort Monmouth, New Jersey.

On 26 March, a second Explorer satellite—actually the third to be fired—was launched successfully by the United States Army at Cape Canaveral, using a modified Jupiter-C. The satellite is essentially the same as the version fired on 31 January (" Four Steps to Orbit," ENGRG., 28 Feb. '58) except that it carries a small tape recorder weighing about ½ lb. and has no external antennae, the body of the satellite being used in this capacity. Its total weight, including the empty casing of the 4th stage rocket, is approximately 31 lb.

The launching was not wholly successful because of a discrepancy in the launching angle of the final stage, which resulted in a deviation from the planned orbit. Early measurements revealed that the satellite was orbiting with a perigee of 125 miles and an apogee of 1,735 miles, taking 115·7 minutes to complete an orbit, and its life expectancy is unlikely to be more than four to six months. Nevertheless, the inclusion of a tape-recorder increases the value of the experiment enormously since cosmic ray data collected throughout the entire path of the orbit can be stored and transmitted from the satellite in bulk over a period of six seconds after it has been interrogated for information by radio from the appropriate ground station, whereupon the recorder's magnetic tape is " wiped " clean ready for the next orbit. In Explorer 1, the bulk of research information was " lost " on the other side of the Earth.

The latest firing follows an earlier unsuccessful attempt to orbit the same research payload on 5 March, when the 4th stage rocket did not ignite.

TABLE I.—*The Satellites Compared*

—	Sputnik 1	Sputnik 2	Explorer 1	Vanguard TV-4	Explorer 2
Launching date	4 October, 1957	3 November, 1957	31 January, 1958	17 March, 1958	26 March, 1958
Weight	184 lb	1,118 lb	30·8 lb	3·25 lb	31 lb (approx.)
Size	23 in dia.	15 to 20 ft long (final stage attached)	80 in × 6 in. (final stage attached)	6·4 in dia.	80 in × 6 in (final stage attached)
Shape	Sphere	Cone-tipped cylinder	Cone-tipped cylinder	Sphere	Cone-tipped cylinder
Angle of orbit to equator	65°	65°	33·5°	34°	34° (approx.)
Orbital period	96·2 min	103·7 min	114·95 min	135 min	115·7 min
Perigee	125 miles	170 miles	219 miles	400 miles	125 miles
Apogee	560 miles	1,055 miles	1,587 miles	2,500 miles	1,735 miles
Transmission frequency	40·002 Mc/s 20·005 Mc/s	40·002 Mc/s 20·005 Mc/s	108 Mc/s 108·3 Mc/s	108 Mc/s 108·3 Mc/s	108 Mc/s 108·3 Mc/s
Launching vehicle	Modified I.C.B.M. (?)	Modified I.C.B.M. (?)	Modified Jupiter-C (4 stages)	Vanguard (3 stages)	Modified Jupiter-C (4 stages)

TABLE II.—*Vanguard Launching Vehicle (TV-4) Compared with Viking High-Altitude Research Rocket, from which its First Stage was Developed*

	Viking II (launched May, 1954)	Vanguard TV-4 (launched 17 March, 1958)		
		Stage 1	Stage 2	Stage 3
Length	45 ft	44 ft (overall 3 stages, 72 ft.)	31 ft	4 ft
Diameter	45 in	45 in	32 in	18-19 in
Diameter, over fins	13 ft 3 in	Not applicable		
Weight, payload	825 lb	—	—	3·25 lb (6·4 in. test-satellite)
Weight, launching	15,005 lb	22,600 lb (including stages 2 and 3 plus satellite)	4,800 lb (including stage 3 plus satellite)	500 lb (including satellite)
Weight, propellent	11,600 lb	Not available		
Propellent	Liquid oxygen/alcohol	Liquid oxygen/kerosene	White fuming nitric acid/ unsymmetrical dimethyl-hydrazine	Long-duration solid
Feed system	H_2O_2 turbo-pump	H_2O_2 turbo-pump	Helium gas-pressure	—
Thrust	21,000 lb × 104 sec	27,000 lb. × 142 sec	7,500 lb	2,300 lb
Control system	Gyro-controlled pivoting rocket motor	Pivoting rocket motors controlled by gyros and pitch programmer in stage 2*		Spin-stabilised
Velocity, cut-off	4,300 m.p.h.	3,700 m.p.h.	9,000 m.p.h.	18,000 m.p.h.
Altitude, cut-off	40 miles	36 miles (separation from stage 2)	135 miles	300 miles (horizontal, nominal entry)
Altitude, max.	158·4 miles	—	—	2,500 miles (apogee)

* Helium gas-jets take over from pivoting motor in controlling trajectory of stage 2 during post cut-off period.

In Parliament

SCIENCE IN INDUSTRY

A brief, 15-minute, Friday debate took place in the House of Commons on 28 March on the application of science to industry. Mr. R. E. Prentice (Labour) moved that the House, being conscious of the fact that this country could only earn its living in the world by maintaining a high level of scientific progress and by applying the results of that progress to industry, should express its concern that the nation's education system was lagging behind modern needs.

That the position was as stated, Mr. Prentice declared in his motion, was shown by the facts that Britain had only 57 science and engineering graduates per million of the population, compared with 136 such graduates in the United States and 280 in Russia, and that British industry was spending so little on research and development—amounting to only 0·8 per cent of the annual value of the country's industrial output, according to a recent survey. This state of affairs was further emphasised by the position that so little use was being made of existing research facilities, as was instanced by the fact that only about 520 firms were affiliated to the Production Engineering Research Association (P.E.R.A.), although some 10,000 were eligible to join.

In these circumstances, the motion advocated that the House should call for a much greater sense of urgency on this problem on the part of the Government, industry, and all concerned in the tasks of expanding scientific research.

SMUG COMPLACENCY

Mr. Prentice began by apologising for the length of his motion. It was due, he said, to his view that the debate was likely to be very short and to his determination to have some record on paper, even if he had very little chance of making a speech.

Just recently, accompanied by other Members of Parliament, he had visited one of the firms undertaking research and development work connected with the building of nuclear power stations, and had been impressed to see young scientists engaged on work of such importance. At the same time, what was being accomplished by the best organisations in British industry was not being done on a sufficiently wide scale. Far too many firms were smug, complacent, and living in the past. Among the firms in the middle group, between the best ones and the worst, there were many which could do more than was being done at the moment.

The facts mentioned in the earlier part of his motion were taken from the annual report of the Advisory Council on Scientific Policy, which was a body that had been set up to advise the Government upon their attitude towards science. The report stated that, whereas British industry was providing from its own resources only the small amount mentioned for research and development, a survey of the United States would indicate that industry there was devoting to these purposes twice as large a proportion of its industrial output, which, in any case, was many times greater than that of Britain.

THIRTY YEARS' EXPERIENCE

With regard to the experience of P.E.R.A., Mr. Prentice said, a spokesman for the Association had told a B.B.C. interviewer that, although it had only 520 engineering firms affiliated to it, there were no fewer than 10,000 firms which could be linked up with it. At least half that number comprised what the Association considered to be potential first-class members—large engineering organisations which could derive considerable benefit from the work the Association was doing. During the ensuing radio programme, a quotation was given from a letter received by the Association from a firm which had been asked to join. The letter stated: "After nearly 30 years in this field we feel that there are few people who would have the experience and qualities to advise us. We are quite satisfied with our past achievements." In place of that attitude, British industry should be pushing ahead, developing fresh techniques and producing new products for sale in world markets.

He wondered whether Government-financed research was being carried out on an adequate scale. It was difficult for a layman to judge some of these matters, but the annual report of the Department of Scientific and Industrial Research, produced in the summer of 1956, had stated that from almost every corner of the Department there were pleas that the resources available for particular purposes were inadequate. The following annual report had deplored the Government's reduction, by £150,000, of the Department's estimated expenditure for 1956-57.

Of the comparatively small total sum now being spent in Britain on scientific research and development, 59 per cent was being spent under this head for defence purposes. He did not suggest that the national defence effort was not important or that it did not require scientific investigation of a high order in this modern age.

He did ask, however, whether existing priorities were right, because the country's solvency as a nation was a part of its defence. He suggested that the priorities, not only of funds but of skilled manpower, between the defence and civil research programmes should be very carefully considered at cabinet level.

ONE MINUTE TO GO

Another point brought out by Mr. Prentice was that the Lord President of the Council had only part-time responsibility for the D.S.I.R. and certain other aspects of research. From the national point of view, either the Lord President or some other senior minister should have full-time responsibility for scientific policy. Further, the Advisory Council should be strengthened by more representatives from both sides of industry.

In a one-minute reply, Mr. F. J. Erroll, the Parliamentary Secretary to the Board of Trade, said that, had he had time, he could probably have demonstrated that the Government were not only alive to many of the questions that had been raised, but that they were doing a great deal more than was realised. That applied to their financial aid, their development of scientific and technological education, and their very wide supervision of industrial scientific research. It being 4 p.m., the debate was automatically adjourned and the Minister's remarks were ended at the commencement of a new sentence.

NATIONALISATION THREAT

In one of the last adjournment debates prior to the Easter recess, Lady Megan Lloyd George (Labour) drew attention to employment difficulties in south-west Wales and to the urgent need for further industrial development in that area. What was wanted in Wales was a diversity of industry and there appeared to be plenty of suitable factory space available—such as the Royal Ordnance factory at Pembrey, the R.A.F. establishment at Pembrey and a food depot at Llandovery. There were now 8,000 persons out of work against 3,500 last October and the final figure was likely to be between 14,000 and 15,000. There was no prospect of alternative work for these men, a great proportion of whom were over 50 years of age.

Lady Megan asked what was being done by the President of the Board of Trade to encourage industries to migrate to south-west Wales. He had said in a speech a week ago that one foreign chemical firm had decided not to go to South Wales because he could not give it a guarantee that the chemical industry would not be nationalised. The President had certain responsibilities in the industrial field and might have been expected to inquire whether the nationalisation of that industry was included in the programme of the next Labour Government. Again, had the Minister taken steps to assure the industrialists concerned that, even if the industry were nationalised, they would be compensated fully for any capital invested in this country, according to the Labour Party's normal practice?

So far the President had brought only one factory to the area, but there was plenty of development work to be done if the Government would undertake it, such as building new roads and schools, the clearing of rural slums, and the improvement of sewerage works and water supplies. There was need for accelerating the electrification of the countryside. The most important aspect of the employment problem in south-west Wales was the site to be chosen for the proposed steel strip-rolling mill for Richard Thomas and Baldwins Limited. South Wales people considered that, in Kidwelly, they possessed the ideal site. Water, limestone and silica were available in large quantities. An adequate labour force was also available.

GOVERNMENT'S AID TO WALES

In this debate also, Mr. Erroll was the spokesman for the Government. He said that, actually, a great deal had been done, and was still being done, for south-west Wales, an area which was generally recognised as being one of peculiar difficulty in respect to the provision of additional employment.

The amount of industrial building approved for the district, from the end of the war until February last, totalled no less than 12½ million sq. ft, and that had all either been completed or was still under construction. One or two major extensions were still in the planning stage by some existing firms, particularly those connected with the non-ferrous metals industries. The traditional industries of the area—coal, steel sheets, and tin-plates—had been substantially augmented by oil refining, light alloy rolling, chemicals, clothing and light engineering. In fact, a major effort had been made to diversify the industrial activities of the area and it had been very largely successful.

It had been stated many times that the Government were prepared to consider favourably applications from suitable firms for the erection of factories, with Government financial aid, under the Distribution of Industry Acts. It would be quite wrong to try to direct firms to particular areas. The Government had a negative power, that of withholding their industrial development certificates, but they adopted the policy of persuading firms to go to places where the Government wished them to. That afternoon, a prominent firm, at present in the South Midlands area, had expressed its readiness to consider establishing a large factory in south-west Wales.

As to the remarks of the President of the Board of Trade, it was, unfortunately, only too true that the firm in question had been influenced by the existence of the Labour Party's nationalisation programme. Parliament was concerned not only with the people of Wales but with all nationalities who might set up industries there. The Labour Party could remove the doubts and difficulties once and for all by publicly renouncing their intention of nationalising or threatening to nationalise certain sections of British industry. He appealed to them to take such action and so remove what was an obstacle, if only a marginal one, to the further expansion of this country's industries.

Traffic at London Airport

Information was desired by Sir Alfred Bossom, Bt. (Conservative), from the Minister of Transport and Civil Aviation regarding the numbers of persons who entered Britain in 1957 through London Airport. Mr. Harold Watkinson told him it was estimated that 450,000 visitors to the United Kingdom entered the country through the airport last year. That figure excluded passengers from the Irish Republic, for whom estimates were not available. The number of persons other than those visitors who entered the country last year through London Airport was 937,000.

Marketing

PROMOTIONAL LEAD

A major step forward in the technique of selling through established distributor-retailer channels —used by so many engineering firms—has been made in the paper trade. For the first time in the history of paper merchantry in Britain a vast publicity campaign has been undertaken by a paper merchant, Spicers Limited, which provides means for the printer or stationer to take part in his own locality. A sample set of Spicers' "Plus Fabric" stationery is available, without charge, to anyone in the trade wishing to distribute it to his customers, carrying his own overprint.

Full details of the advertising campaign are given in a well produced book which describes how the plans will be carried out and when they will take place. "The aim," says the group sales and marketing director in a covering letter, "is to promote more business from consumers of paper and print, to the combined benefit of Spicers and their customers." In addition to the free sample set mentioned above, a block service for local advertising is also provided free of charge. The advertising campaign will be launched in the early spring "on an unprecedented scale" in provincial newspapers as well as national dailies and magazines.

There is much to commend Spicers' approach. The return of competition in the paper field, and particularly in the markets constituted by printers and stationers, had caught the trade unprepared and was having a profoundly disturbing effect upon it. The large stationery manufacturers and merchants were disappointed at the apathy and lack of enterprise they found among their customers. Some were inclined, therefore, to by-pass the trade and sell direct to the printer's or stationer's customers, particularly the larger ones. Printers and stationers were consequently weakened by this competition (according to most of them, very unfair) from their own suppliers on their own doorsteps. The effect, therefore, tended to be to make an unsatisfactory state of affairs worse. The stationery manufacturers and merchants are not equipped to serve retailers and end-users in all areas, and the burden of supplying the small buyer was therefore left to the local printer or stationer, who was becoming less and less able to give good service or to finance even the lukewarm sales effort made since the war.

A detailed investigation of this problem led Spicers to conclude that the printer and stationer constituted the correct sales channel for flat paper and stationery. Any effort to increase sales of Spicers products must therefore involve as much participation as possible from both. Hence the full announcements of the campaign, the free blocks and sample sets. Well backed by the company's representatives, this promotion should act as a "shot in the arm" to the trade in general. It will help businesses to effect the transition from a sellers' market, where keeping customers happy while waiting for delivery was the main task of any salesmen on the books, to one in which sales are dwindling and hard to make. Spicers' lead will be watched with interest by many companies outside the paper trade, for the same problem of injecting new life in wholesale and retail channels exists almost everywhere.

B.E.A.M.A. on the F.T.A.

The annual report of the Council of the British Electrical and Allied Manufacturers' Association dwells at some length on the problems associated with the constitution of a free trade area in western Europe. Pointing out that £51·4 million of the industry's total exports (18½ per cent) went to O.E.E.C. and Rome Treaty countries, the report comments that this reveals "how deeply the industry is concerned with the European Free Trade Area proposals now being considered by the Government."

B.E.A.M.A. make three main points. First is the danger which the reduction of tariffs envisaged under the proposals brings to the industry: they write of a "long and possibly painful re-adjustment" which may have to take place in the suggested span of 15 years and conclude that "it is fair to say that electrical manufacturers in general are opposed to the complete elimination of tariffs." The industry's interests are so wide, however, that it is difficult to define a general attitude. The second point relates to the development of relationships with members' counterparts abroad in such matters as the interchange of information, patents, know-how and personnel. The report comments that "it is mainly by mutual co-operation in industry that many of the problems of freer trade will have to be solved," but warns that British industry may be handicapped in effecting this by the effects of the existing legislation on "so-called restrictive trade and monopolistic practices." The third point emphasises the need for protection at home against the entry of "cheap and shoddy domestic goods from the Continent." B.E.A.M.A. hope that an economical system of testing and proving, which includes the use of existing testing facilities (as in the B.S.I.-C.S.A. Approvals Scheme) will be established.

Are Your Sales Insured?

An unusual facet of insurance is discussed in an article published in the March issue of the Chamber of Commerce *Journal*. It relates to insurance against a full income, to protect the business from trading hazards which could result in a heavy loss. Although, as the article points out, there are many factors which can cause income to be reduced—trade recessions, competition, changing fashions, are a few examples, "insurance against these contingencies is so rare that it can be ignored." The most usual contingency against which insurance is taken is "the inability to supply goods or services."

The article discusses the factors to be taken into account when taking out such insurance cover. Production or sales can be interrupted by a fire, the breakdown of big machinery or the failure of power supplies. The loss is normally assessed in accordance with an agreed formula which takes into account the figures of the last financial year prior to the interruption, and the reductions effected in parallel with the loss of sales in certain operating expenses—"variables"—which can be related to the size of turnover. It should include, however, "the extra cost of keeping the business going as far as possible." As is pointed out in the article, the insurance "is not only an insurance against lost sales, but also against lost efficiency." It would be interesting to know how much of this type of insurance exists, and probably to the advantage of the insurance companies to release the information.

Opportunities in Czechoslovakia

An invitation to meet informally Mr. Roman Kubicek, the deputy head of Strojimport—the corporation for importing plant and machinery into Czechoslovakia—yielded useful information on the opportunities likely to develop there for British firms over the next few years. The Czechs are interested in buying British. Mr. Kubicek was here to place orders—he placed inquiries for between £2½ million and £3 million of machine tools and chemical plant and he has expressed interest in road making machines, construction plant and equipment, locomotives and many other engineering products. In addition, there is room for the supplier of complete production plants on the style of the Russian motor tyre factory which is being equipped by Rustyfa, a consortium of British companies formed for the purpose. Most of Czechoslovakia's imports of engineering products are currently supplied by western Germany (the United Kingdom provides only about 3 per cent of total machinery imports). Clearly, Mr. Kubicek and his colleagues would like to place more orders in the United Kingdom, partly because they dislike being so dependent upon one country and partly because they like us better than the Germans. Memories of 1938 doubtless linger on in many places.

Mr. Kubicek took the opportunity of this informal meeting to make a few good natured criticisms of British exporters. Commercially we have not done too well and the Czechs have the impression that British firms do not consider the market very interesting and therefore do not try very hard. The Germans, on the other hand, go all out for orders.

Imports of British machinery are expected to total 31 million crowns (£1½ million) this year, and in Mr. Kubicek's view could reach £4 million to £5 million a year. There is scope here for steady sales of the most modern and expensive plant—as our hosts, the British Council for the Promotion of International Trade, were at pains to point out.

Leipzig 1958

Once again the Leipzig Spring Fair—held from 2 to 11 March—proved a popular meeting place between east and west. The statistics just released are a useful measure of the interest being shown by western Europe in developing trade with Soviet bloc countries, now greater than ever as import demand from the western hemisphere declines. Some 9,700 exhibitors took part from 43 countries, and stand space totalled 3·1 million sq. ft. The main western participation came from Western Germany, whose 1,464 exhibitors took 397,000 sq. ft. The remainder of western exhibitors, about 1,300 in all, occupied 180,000 sq. ft.

Among the 41 foreign countries exhibiting, just over half organised collective displays. Thirty-five sent Government, Parliamentary or Trade Delegations, including Britain, France, Italy, the Netherlands and several Latin American countries. The new Arab Republic was represented in strength. Eastern European Governments are clearly in favour of developing trade with the west. The early calling of a "world trade conference" was suggested. "Normalisation" of trade relationships between east and west Germany was also called for. The trend of events suggests that the Leipzig Autumn Fair, to be held from 7 to 14 September, will prove a timely opportunity for those engineering firms who have not yet staked a claim in the markets of eastern Europe to do so. The present dominance of Western Germany is a challenge which needs answering.

Test Case on Restrictive Practices

The Restrictive Practices Court is likely to hear its first case in the London Law Courts during October. This was announced recently by Mr. R. L. Sich, Registrar of Restrictive Trading Agreements, with the comment that he did not think it possible to have a case ready before that time, but that "from then onwards there should be a constant stream of cases for the Court to consider."

On an average each case is expected to take about a month "because of their technical and complicated nature." Mr. Sich anticipates that the decisions in the first 40 cases might decide the future of a further 150. They have been chosen with that probability in view and the general situation should become clearer as soon as the sittings have been under way for a few months.

Research and Development

RADIO AIDS THE NAVIGATOR

On 27 and 28 March a convention was held at the Institution of Electrical Engineers on " Radio Aids to Aeronautical and Marine Navigation." Some 17 papers were read in five sessions. At the opening session a valuable introduction to the subject was given in a paper " A Review of Radio Aids to Aeronautical and Marine Navigation " by Mr. C. Williams.

The author opened his paper with a word of caution: " At a Convention of this kind, the technical aspects of radio navigation are liable to predominate over the operational aspects, but we must guard against this, for only by an intelligent interest in both considerations can the engineer and scientist make the best contribution to the user's needs." Mr. Williams then went on to point out that a demand for improved aeronautical radio navigation has come about because of the increasing density of air traffic and the need for aircraft to operate regularly in adverse weather conditions. In maritime applications the need to eliminate delays in the movement of ships during bad visibility has encouraged the development of ship-borne radar of greater accuracy and the provision of more adequate navigational services, particularly for coastal navigation.

The insufficiency of radio channel space and the need for systems of greater resolution have extended the used radio spectrum further into the microwave end; the need for long-distance navigation facilities has stimulated greater interest in wave propagation at very low frequencies, of the order of 14 kc/s.

In radio communication the path travelled by the waves from transmitter to receiver is of little importance if the signals are intelligible. In radio navigation much more fundamental aspects of wave propagation present themselves. The path of the waves and their velocity along the path are matters of prime importance. The accuracy to which the propagation velocity of electro-magnetic waves is known conditions the accuracy of all radio navigation systems. Research efforts directed to establish the true velocity and its variations in a medium of variable density, such as the atmosphere, have been of great importance. Of equal importance has been the need to study the variations in propagation that occur when a wave is travelling close to the ground, and the disturbances which occur when marked changes in the conductivity and dielectric constant of the ground take place, for example at the coast.

Present techniques allow time measurement of 0·1 microsec, and the velocity of radiation in the microwave band is known to within about 0·01 per cent. At short distances the predominating error arises in measurement of the time interval. But at distances greater than 150 km the predominating source of error is the lack of knowledge of the true velocity, the error arising being directly proportional to the propagation time.

There are two basic types of navigation. A position can either be derived relative to a fixed point, or it can be derived in relationship to a fixed framework, called the co-ordinate system. The process of dead reckoning, which comes into the first category, involves integration of movement with time to ascertain the new position, and the accuracy depends directly on the quality of the information used and the integration time. Examples of new techniques employing integration processes are automatic dead reckoning, Doppler, inertia, and the use of stable frequency sources. The error in position of one craft using such a technique is unrelated to the error in position of another craft that may be near it; and the measures necessary to prevent collision are obscure. This limitation is the primary reason for the use of systems that lay down a fixed co-ordinate framework in which the craft move. If this co-ordinate framework is common at any one time to all the craft within its coverage, the relative errors of positions of all craft are all highly correlated and the degree of correlation will increase as the craft approach each other. Under these conditions it is practicable to derive a statistical figure for the safe separation of craft in order to avoid collision; the value derived will be considerably less than that for integration systems.

INERTIAL NAVIGATION

One of the shortcomings of radio navigational aids is that they are subject to short term inaccuracies, arising, for example, from fading or interruption of the signal. The contribution radio aids have made to navigation can be appreciated from the large number of papers presented at the Convention, but a significant departure from the general run of papers was " The Combination of Inertial Navigation and Radio Aids," by Mr. A. Stratton. The author suggested a combination of mechanical and electronic systems, in order to enjoy the advantages, and eliminate the disadvantages, of both.

Inertial navigation devices have been receiving increasing attention in the field of long range missiles. Radio guidance is susceptible to jamming by enemy radio interference. Therefore, the self-contained inertial system that requires no outside signals is gaining preference. It has been suggested, for example, that the Atlas I.C.B.M. will have an inertial system when it becomes a production model, instead of the command radio guidance system carried by the prototype.

The inertial system relies on the fact that if a known mass is carried in a vehicle and constrained to take part in its motion, then, provided that the constraining forces and moments can be measured sufficiently accurately and the gravitational forces and moments are known, the motion of the mass, and hence the vehicle, can be determined. A rigid body has six degrees of freedom in space—three translational and three rotational—and it follows that to determine completely the motion of a rigid body one must have six independent equations of motion. In an operational vehicle it is not essential for all six equations to be solved by measurements on a single mass and in practice from one to three degrees of freedom are determined by measurements on one mass. The basic instruments are gyroscopes and accelerometers, which detect the angular and linear motions respectively. An important requirement is extremely low wander rate of the gyroscopes. As an example of the mechanical problems involved, a typical gyroscope with an angular momentum of 10^7 g-cm²/sec, operating in a field of 1g, will change its precession rate by 0·1° per hour (a modest performance for inertial navigation) if the centre of mass shifts 10^{-6} in or the parasitic torques change by 5 dyne-cm.

The particular characteristic of available inertial systems is that they provide good short term accuracy at a high data rate. By comparison, a ground radar, for example, provides good long-term accuracy at a low data rate, conditioned by the speed of rotation of the aerial. Mr. Stratton suggests that the best progress might be made in the future by the combination of radio navigation and inertial aids. He outlines the properties that might be expected of a mixed system.

MARINE RADAR

In a paper, " Survey of Recent Developments in Marine Radar," the author, Mr. A. L. P. Milwright points out that since the Radiolocation Convention at the Institution of Electrical Engineers in 1946, no fundamental changes have taken place in the marine radar field. The techniques then described have been improved and applied to marine radars, and improvements have been made in equipment reliability and manufacturing techniques.

In considering future developments, the author remarks that the true-motion display, although a great advance on the relative motion display, suffers from two disadvantages: the time taken to determine a change of course by another vessel at a long range is several minutes, and the time taken to determine both true course and relative course is even longer. To overcome these disadvantages consideration is being given to the use of radars of higher discrimination in order that the aspect or course of a vessel can be determined at a glance by the shape of its echo, and its relative course can be determined by the use of a standard relative display. It seems likely that for the greater discrimination required it will be necessary to operate in the Q-band (wavelength 0·86 cm), if the aerial size is to be kept within manageable limits. The author suggests that a simple form of stabilisation of the aerial will be necessary so that a narrow vertical beam width (4°) can be tolerated. This, together with circular polarisation, is necessary in order to reduce the amount of rain clutter.

DOPPLER

An excellent outline of the early work on the application of the Doppler principle to the measurement of ground speed and drift angle of aircraft is contained in " Doppler Navigation," by Mr. J. E. Clegg and Mr. T. G. Thorne. They point out that the use of the Doppler principle to measure the ground speed of an aircraft was suggested in 1930. During the Second World War it was found that the search radar set of an aircraft could, with only slight modification, be used to measure drift angle. But the system was ineffective over water and the device was not developed. Then in 1946 experiments were made at the Royal Radar Establishment using a pulsed transmitter. To make the system work it became clear that a pulse repetition frequency of 20 kc/s was needed; at that time the frequency was not considered practical.

But by 1950 it became possible to produce a successful system, and a contract was placed with Marconi's Wireless Telegraph Company Limited for the development of equipment for the R.A.F. A complete development prototype flew in 1952 and with minor modifications this design is the present production airborne installation, approval for production being given in 1954. An account of the equipment, A.R.I. 5851, was given at the Convention in a paper " An Airborne Doppler Navigation Equipment," by Mr. G. E. Beck and Mr. T. G. Thorne.

The minimum height at which the equipment will work is 300 to 400 ft. The maximum height at which the equipment has flown is 53,000 ft, and signal-to-noise measurements indicate that it should operate at heights of up to 70,050 ft. Over sea, the maximum height depends on the surface wind. When this is 5 knots the maximum height is 30,000 ft; for winds between 5 and 10 knots the maximum height is 40,000 ft.

The transmitter is a pulsed X-band (3 cm) magnetron with a pulse repetition frequency of 50 kc/s. The peak power is 7 kW, and a pulse length of 0·5 microsec, together with intermittent operation in bursts of 40 millisec every half second, reduces the mean power to 10 watts. During service trials to measure the total effective error in flight it was concluded that under normal conditions the total error does not exceed 0·2 per cent of the distance travelled and 0·2° of the drift. As a general consideration, a day-to-day accuracy of navigational position better than 1 per cent can be expected.

In another paper, " Low-Power C.W. Doppler Navigation Equipment," by Mr. J. E. Clegg and Mr. J. W. Crompton, it is suggested that the pulse technique has probably been pushed to the limit and that to improve the performance further and to simplify equipment design it

might well be that the continuous wave system shows the most promise. In the paper, the development of a low-power aid which has been designed for use in marine reconnaissance aircraft is described. Low-voltage klystrons combined with high-gain fixed aerials provide adequate system gain for operating over all surfaces except the calmest water. The equipment operates at heights between 100 and 10,000 ft and in the speed range 100 to 250 knots. Further design work will be required if the speed and altitude range are to be extended.

In a paper " A Mathematic Analysis of Collision Course Prediction by Doppler Radar," by Mr. H. R. Whitfield and Mr. C. M. Cade, the equations of the relative motions of ships at sea were examined and it was shown how these might be related to the Doppler frequency obtained by a suitable auxiliary radar. A system was proposed in which the range and bearing of the target are given by a conventional radar p.p.i., while the Doppler radar gives the magnitude and sense of the radial component of the relative velocity and also indicates the magnitude of the derivative of radial velocity. From these data the course and speed of the target may be determined and an automatic computer can be arranged to show the time to the point of nearest approach.

OVER LONG ROUTES

In a paper " Survey of Long Range Radio Navigation Aids " by Mr. J. C. Farmer it was pointed out that there has not been any marked change in the requirements for long range navigational aids at sea during the last few years and that it does not seem likely that there will be any such change unless atomic-powered submarines come into every-day use. It was somewhat surprising, however, that an enormous increase in long-distance air travel had taken place without the presence of a universal long-distance radio aids to navigation.

The radio-compass or automatic direction finder is still the most widely used navigational aid for medium and long range navigation. It operates in the medium and low frequency bands and consists of a receiver with a motor-driven loop aerial.

The Consul system, which is derived from the wartime German Sonne system was planned for widespread use as recently as 1954, but economic factors coupled with the probable necessity to provide a more rapid, direction indicating system for jet aircraft, may, thinks the author, make it unlikely that the plan will be fully implemented. Considerable marine use is made of Consul, particularly by fishing vessels.

Loran chains have also operated in several areas for more than a decade. The basic system operates in the upper part of the m.f. band, usually about 2 Mc/s. Various other long range aids under development were listed by Mr. Farmer, and a summary is given below.

Delrac

This system is a continuous-wave hyperbolic phase-comparison system which would operate in the 10-14 kc/s band and which, it is hoped, could provide high-accuracy fixing-cover on a world-wide basis. The system at present proposed would operate on a time-multiplex and frequency-multiplex basis. A master and a slave station are positioned on a 1,000 mile base line, and the phase relations between groups of signals from a pair of stations are displayed on a meter, the reading of which selects the position line passing through the user's location. Fixes are obtained by using two or more pairs of stations in conjunction with overprinted charts. Preliminary studies have indicated that, with a ground-station radiated power of 5 kW and a 5 c/s receiver bandpass, ranges up to 3,000 miles might be obtained. Assuming an optimum positioning of stations, the number of which might not exceed twelve pairs, world coverage having a fixed accuracy better than 10 miles on a 95 per cent probability basis could perhaps be obtained. It would have a common appeal to shipping and aviation interests.

Omega

The United States has been working on a system similar to Delrac. Known as Omega it is a development of an earlier system called Radux and is a hyperbolic system operating in the 10-14 kc/s band in which the phase comparison of continuous wave signals enables position lines to be determined. The earlier Radux system operated on 40 kc/s modulated at 200c/s, to which was added subsequently a vernier 10 kc/s c.w. phase-comparison system to provide high accuracy. It is claimed, as a result of v.l.f. propagation studies, that a dual-frequency c.w. phase-measurement system on 10 kc/s would be practicable. A network of Omega stations would consist of from three to six synchronised stations, each operating on a basic and secondary frequency differing by 500 c/s. The range is expected to be 5,000-6,000 miles, but large powers and aerial systems are needed.

Cytac

A system now under evaluation in the United States is known as Loran-C, or more commonly as Cytac. It is a pulse hyperbolic system designed to operate in the band 90-110 kc/s. A chain consists of a master station and at least two slave stations, the latter transmitting pulses synchronised with those of the master. The Cytac receiver measures the time differences of arrival of the master pulses and each of the slave pulses and thus obtains a positional fix. At the chosen frequency, and with a peak indicated power of 60 kW, tests carried out indicate that ground wave ranges of about 2,000 n.m. over sea and 1,200 n.m. over land can be obtained. Field trials in the United States using fixed monitor stations are claimed to show errors, averaged over night and day at all times of the year, ranging from 150 ft at 400 n.m. to 1,000 ft at 1,400 n.m., using ground wave propagation.

Navarho

This system, under development and evaluation in the United States, is an integrated system comprising two elements, Navaglobe (azimuth) and Facom (distance), which have been separately developed. It provides distance and bearing information directly to the pilot or navigator and therefore is what is known as a rho-theta aid, as distinct from a hyperbolic system. It is the long-range equivalent of VOR/DME or Tacan.

Distance information of Navarho is obtained by phase comparison of two signals, one from the ground station and one locally generated in the aircraft. This technique obviously calls for an extremely high frequency stability in the ground transmitter and in the aircraft receiver; it is claimed that for the latter a stability of one part in 10^9 for 12 hours, necessary to provide acceptable accuracy, is obtainable. The azimuth information is obtained by comparison of amplitude. The ground station consists of a transmitter having a radiated power of 4·2 kW and operating in the frequency band 90-110 kc/s. The bandwidth is 20 c/s. The aerial system consists of three towers 625 ft high located at the corners of an equilateral triangle, of side approximately 0·36 to 0·4 wavelengths. These are excited sequentially in pairs, with co-phased equi-amplitude power. In the aircraft receiver, the amplitude signals are gated and summed vectorially to give the bearing information.

Flight trials of the Navarho system were carried out over a period of a year from May, 1956, and observations were also made from ground monitoring stations in the United States. The ranges obtained varied from 1,100 n.m. over land by day to 2,000 n.m. over water by night. The distance error obtained for 95 per cent of the time varied from ± 9 n.m. to ± 35 n.m. and the azimuth error for the same period varied between ± 3·88° to ±4·42°.

Dectra

This is a hyperbolic system operating in the low frequency band (70 kc/s) in which stations are located so as to provide a series of tracks between the terminals of a long route, together with a ranging pattern. At one terminal a single frequency F_1 is time shared between a pair of stations A and B. At the other terminal a single frequency F_2 is time shared between stations C and D. The difference between the frequencies is arranged to be a submultiple of both.

In series of tests using Valiant aircraft, stations were only available at one terminal, Newfoundland; but tracking tests were carried out across the Atlantic. The largest standard deviation of tracking error on any flight in terms of distance was ± 2¼ n.m. for the section between Gander and longitude 20° W, about 1,300 n.m. In the second phase of the Dectra trials, terminal stations in Scotland will be available and ranging or distance measurement will be checked.

Radio Mesh

This system is under development in France. If two stations, at a distance, transmit signals modulated by adjacent but distinct frequencies, the signals are received in phase along a moving interference pattern, or equiphase line, hyperbolic in shape. The speed is governed by the choice of signal frequencies, and the distance between the two stations is thus scanned at a predetermined rate. A counting device on the aircraft measures the time interval between the passage of two equiphase lines and position lines are derived. In a further variation of the system a position signal is transmitted to the control station when an equiphase line passes through the aircraft. So far as is known, no test results have been published.

Radio Sextant

The foregoing systems have all been ground-based. However, a number of self-contained airborne systems are being developed. Of these the Doppler and Inertial systems have already been mentioned. There is one other technique of which more may be heard in the future. This is an application of radio astronomy, and operates by detecting the radio waves from celestial bodies, for example, the sun. Suitable receivers operating in the centimetre bands, to reduce aerial size, can detect solar radiation and by using lock-and-follow techniques can continuously record elevation and azimuth. So far as is known, equipment to receive solar radiation has been designed and tested in the United States for use on board ship, and at least tentative designs exist for airborne equipment. The marine equipment operates on about 1·9 cm and, it is believed, has a tracking error of 2 min.

Earth Satellite Beacons

An alternative to the development of highly sensitive receivers for the detection of solar radiation is the provision of a celestial radio source of sufficient power that ordinary receiving techniques can be used. The suggestion that an artificial earth satellite equipped with a transmitter operating above 100 Mc/s could provide a valuable navigational aid was put forward in the opening paper by Mr. Williams. This is not a new suggestion but it is a pity that detailed consideration could not be given to it in one of the papers read at the convention.

Other papers read at the convention but not mentioned above were:

" The Decca Navigator System for Ship and Aircraft Use," by C. Powell.

" General Aspects of Short-Range Rho-Theta Systems," by C. E. Strong.

" Tacan: a Navigational System for Aircraft," by W. L. Garfield.

" Current Direction Finding-Practice," by H. G. Hopkins and B. G. Pressey.

" The Practical Evolution of the Commutated Aerial Direction-Finding System," by C. W. Earp and D. L. Cooper-Jones.

" A Survey of Approach and Landing Aids," by W. J. Charnley.

" Precision Approach Radar," by G. J. Moorcroft.

" A Survey of Harbour Approach Aids," by A. L. P. Milwright.

" The Application of Radio Altimeters to Aircraft Approach and Landing," by M. P. G. Capelli A. E. Outten, and K. E. Bücks.

" Advances in Ground Radar for Civil Aviation," by E. Eastwood and C. D. Colchester.

Continuing **Research and Development**

BRISTOL'S HIGH-ALTITUDE TEST PLANT FOR RAM-JET ENGINES

Main Supply Systems

Concluded from page 438

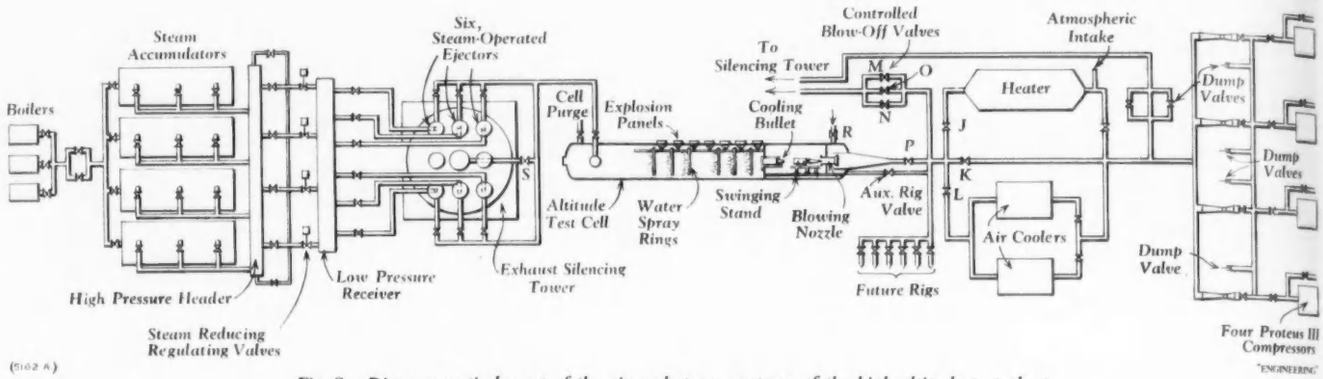


Fig. 8 Diagrammatic layout of the air and steam systems of the high-altitude test plant.

BRISTOL Aero-Engines Limited have recently brought into operation a new high-altitude test plant at Gipsy Patch, Bristol, for the development of large ram-jet engines. In last week's issue of ENGINEERING we gave a general description of the facility, with details of the test cell itself and some of the instrumentation. We conclude the report this week with details of the plant's main systems—air, steam, fuel, and water supply.

AIR SUPPLY

Fig. 8 is a diagrammatic layout of the air and steam systems of the high-altitude test plant.

The four Proteus compressors which supply air to the test cell are located across a road, in No. 1 air station. They are driven, through step-up gearboxes, by direct current motors developing a total of 26,000 h.p. (2 hour rating) or 21,000 h.p. continuous. With all four compressors in operation, the maximum delivery pressure is limited to 6 atm., by the available power; the total mass flow is 150 lb per sec, and the delivery temperature is 260° C. With only two compressors operating, a delivery pressure of 8 atm. can be obtained with a mass flow of 84 lb per sec and a delivery temperature of 315° C.

Still within the air station building, the delivery air from each compressor is piped, through a shut-off valve, a non-return valve and a Venturi to a manifold from whence a single 36 in diameter pipe takes the air from all the compressors across a road into the high-altitude building. The non-return valve and the Venturi are safeguards against compressor surging, preventing the back-flow of air to the compressors. A further safeguard is the provision of compressor dump valves which can be pre-set from the control room of the air station to blow off rapidly in the event of back pressure on the compressor building up too close to the surge pressure. These dump valves are connected to further dump valves in the main delivery duct in the high-altitude building so that stored energy in the high-altitude system pipelines is released automatically through the exhaust silencing tower, simultaneously with the relief of compressor back pressure.

Passing into the air-conditioning room, the air can be led through a storage heater, or through two Serck water-cooled air coolers, or it can by-pass both heater and coolers or it can do a combination of these things, quick-operating gate valves in the outlet lines permitting the mixing of air to give the desired operating temperature.

The coolers, which work in parallel, are of standard design and are capable of cooling the maximum air flow from 260° C to 95° C with a maximum water flow of 50,000 gal per hr. The design of the heater, on the other hand, was one of the major problems of the plant, since it was required to raise 80 lb per sec of air from 260° C to 450° C and to permit the selection of different temperature conditions, to an accuracy of ±5° C, within 10 seconds. The solution was provided by a 1,500 kW electrical storage heater made by Incandescent Heat Co. Ltd., capable of storing $4{\cdot}5 \times 10^6$ C.H.U., and requiring some four hours to heat up from cold to maximum heat capacity. As shown in Fig. 9, it consists of heavy steel matrices (36 tons in all) heated by electrical elements. Lengthwise it is divided into three sections, separated by dampers which can be adjusted to regulate the proportion of air passing through each matrix section so as to attain the most effective control of the final air temperature. These dampers, pneumatically actuated, are regulated by Honeywell-Brown temperature controllers which can be remotely pre-set from the control room to maintain the desired air temperature at the outlet of each matrix section. In each section, the heater elements are controlled to maintain the preselected matrix temperature by a Foster temperature recorder/controller; and should the matrix temperature or that of the heater elements become excessive, the electrical supply is automatically cut out.

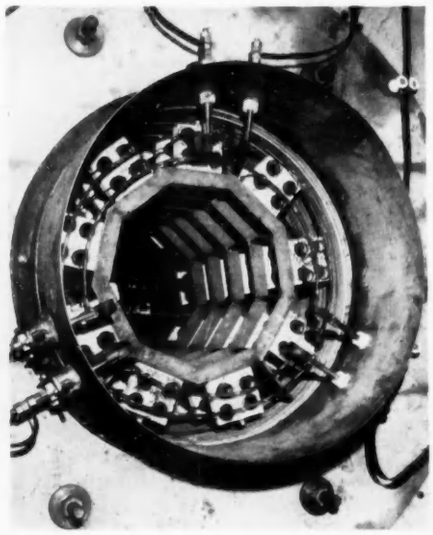


Fig. 9 The electrical storage heater comprises three sections of heavy steel matrices heated by electrical elements. The sections are separated by adjustable dampers regulating the proportion of air passing through.

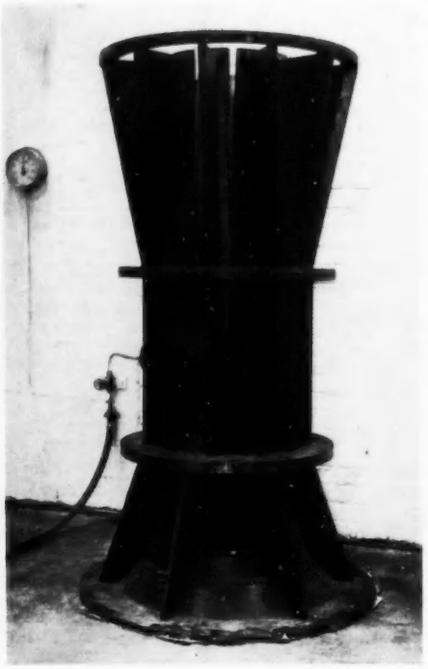


Fig. 10 The Bristol slotted blowing nozzle for transonic tests: Mach number varies directly with $\sqrt{}$ the upstream air pressure.

AIR CONTROL VALVES

In starting up a low or medium altitude test the rig valve P (Fig. 8) would be closed and the air supply by-passed to the exhaust tower. Air temperature having been finally adjusted by the mixing valves J, K and L, the pressure is adjusted by the controlled blow-off valves O, M and N—O being the main valve and the smaller valves M and N acting as trimmers. The rig valve is then opened and the blow-off valves closed as necessary to give the required pressure and mass flow at the blowing nozzle in the test cell. (When the test cell is used for testing auxiliaries instead

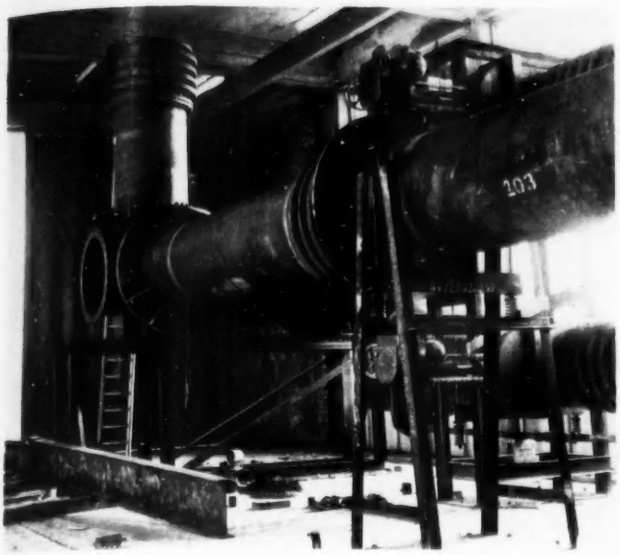
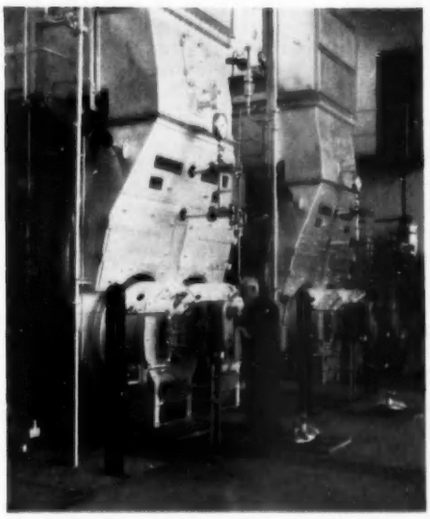


Fig. 11 (left) The ducting incorporates expansion bellows to take up thermal stresses.

Fig. 12 (below) Three Cochran Sinuflo Economic boilers generate 37,800 lb per hour of dry saturated steam for charging the steam accumulators.



of whole engines, the smaller auxiliary supply line and rig valve are used). As mentioned in the previous article, acceleration tests simulating launch conditions can be carried out by means of an automatic master control on the rig valve P and the blow-off valve O, whereby the full mass flow can be directed from the by-pass line to the test cell in three seconds, the Mach number at the Bristol slotted blowing nozzle (Fig. 10) varying directly with the upstream air pressure.

Another crucial design problem was set by the main conditioned-air control valves—referring to Fig. 8, the mixing valves J, K, L, the controlled blow-off valve O, the main rig valve P, and the air bleed-in valve R (also used for fresh-air purging of the cell after a test). Each of these valves controls a 36 in diameter pipeline, and is required to operate within three seconds and to withstand a temperature of 450° C, without leakage. Such valves are not in general demand, but hydraulically-actuated wedge gate valves, supplied by Rotork Limited, have successfully met the rigorous specification.

The smaller air valves, operating generally under less rigorous conditions, are piston or slide valves, actuated in some cases hydraulically and in others electrically. The two largest valves are 5 ft diameter motorised gate valves in the cell exhaust duct which have to withstand an operating temperature of up to 200° C, and they are not required to respond in seconds. To cater for thermal variations, the ducting throughout the plant incorporates expansion bellows (Fig. 11).

STEAM EJECTOR SYSTEM

When simulating high altitude, the necessary depression in the test cell is created by closing the direct exhaust shut-off valve S (Fig. 8) to the exhaust tower and bringing into operation some or all of the six steam ejectors. These ejectors, believed to be the largest ever used in the United Kingdom, were made by Hick-Hargreaves Limited to Bristol's requirements. Two alternative nozzle sizes can be used, passing respectively 33 lb per sec or 40 lb per sec of steam each. The ejectors operate at a steam pressure of 95 lb per sq. in gauge and are capable of sucking an air mass flow of 160 lb per sec down to a pressure of 8 lb per sq. in or, at zero mass flow, of producing a minimum test-cell pressure of 1·6 lb per sq. in absolute.

So far as possible, the steam supply system employs well-tried components. Fig. 12 shows two of the three Cochran Sinuflo Economic boilers, 9 ft 6 in in diameter and fitted with economisers, which together generate 37,800 lb per hour of dry saturated steam at 250 lb per sq. in gauge, with cold feed. The boilers operate on oil fuel, and are equipped with automatically controlled Hamworthy rotary spinning cup burners.

The boilers are used to charge four Ruths steam accumulators, each 64 ft long and 12 ft in diameter, mounted on pylons above a water reservoir. They have a total storage capacity of 100,000 lb of steam when discharging between the maximum pressure of 250 lb per sq. in gauge and 105 lb per sq. in gauge. Pressure-retaining valves ensure that constant water pressure is maintained in the boilers irrespective of the pressure in the accumulators. From the accumulators the steam at 250 lb per sq. in passes to a high pressure header and thence, through four paralleled isolating and pressure-reducing valves, to a low-pressure receiver. These Foxboro-Yoxall reducing valves have the onerous duty of reducing 900,000 lb per hour of steam from 250 lb per sq. in to 95 lb per sq. in gauge and regulating at the latter pressure—and that is the explanation of why four valves are used in parallel instead of a single valve. From the low-pressure receiver, six individual pipelines connect with the six steam ejectors through isolating valves. In operation, the steam supply to the ejectors is controlled

Fig. 13 One of the four Ruths accumulators, which were transported by road, unloading on site.

Fig. 14 The fuel pump room: two centrifugal backing pumps feed into the suction side of six variable high-pressure constant-flow pumps.

Continuing
Research and Development

entirely by the reducing valves, mentioned above, all the other steam valves being opened. The solenoid operating the steam reducing valves is wired into the emergency control circuit so that the steam supply is automatically shut off when any of the emergency push-buttons are operated.

In starting up from cold, it takes a matter of days to charge the steam accumulators fully; but, with steam pressure raised in the boilers, the accumulators can be re-charged after a test in about 2½ hours, during which time any necessary adjustments can be made in the test cell.

Fig. 13 shows one of the four Ruths accumulators, which were transported by road, being unloaded on arrival at the site.

FUEL FOR THE RAM-JETS

The fuel for the ram-jet is stored in six tanks outside the main high-altitude building, on the side remote from the control room—four 6,000 gal tanks for kerosine and petrol, and two 1,000 gal tanks for unorthodox fuels. Adjacent to the tanks is the pump room in which are housed two Harland centrifugal backing pumps which feed into the suction side of six Oswald and Ridgeway Beacham fixed swashplate variable-pressure pumps, a battery of small high-pressure pumps being selected in preference to one large pump because of the wide range of fuel flows demanded by the ram-jet engine. The Oswald and Ridgeway pumps operate at constant speed and a constant flow of 11,000 lb per hr each at a maximum working pressure of 1,000 lb per sq. in gauge. To damp out the pulsation in the high-pressure delivery there are Greer-Mercier accumulators, and a Hale-Hamilton pressure controller is also incorporated in the output line. A general view of the fuel pump room is shown in Fig. 14.

The high-pressure delivery is taken into a calibrating room in which the flow is metered through transmitting Rotameters and a Bailey meter, indicating in the control room. From the calibrating room, the high-pressure delivery is divided into three lines passing through a manifold plate in the sidewall of the test cell and connected to the primary, secondary and tertiary fuel lines in the ram-jet. Each high-pressure line is controlled by multiple Saunders spherical valves which provide the necessary fine control of fuel flow over a range from zero to 60,000 lb per hour. For very fine control at low flows, balanced pressure valves designed by Bristol Aero-Engines operate in parallel with the throttle valves. The latter are remotely operated by Exactor controls. It is also possible to pre-set the rate of change of fuel flow on an automatic device, to simulate flight conditions.

Within the calibrating room, a branch pipe of each of the high-pressure lines is led to a calibrating tank in which, before installation in the test cell for a combustion test, the ram-jet fuel system is calibrated.

WATER SUPPLY

As already mentioned, there is a storage reservoir below the steam accumulators, with a capacity of 250,000 gal. This supplies water to the boiler feed-water treatment plant and storage (12,000 gal capacity), and also provides cooling water supplies for four separate systems: the test-cell exhaust-cooling spray rings and spray cone; the Serck air coolers; the engine-tail pipe and test instrument cooling system; and the explosion-vent-cooling and exhaust-tower wash-down system. In all there are six water-pressure pumps with a total capacity of 175,000 gal per hr, of which 50,000 gal per hr is supplied at 45 lb per sq. in gauge to the air coolers. The other cooling services are supplied at 90 lb per sq. in.

This concludes our description of the main features of Bristol's new high altitude facility at Gipsy Patch. The plant itself is only at the first stage of its development, and the layout has been designed to allow plenty of room for growth. There is provision for increasing the boiler capacity by 100 per cent, and the accumulator capacity can be similarly increased. The high altitude building itself is located so as to permit the erection of a second test cell to be served by the same control room.

CONTRACTORS AND SUPPLIERS

The main contractors for the plant were as follows: Buildings and services, Sir Alfred McAlpine and Son Limited. Test cell, Babcock and Wilcox Limited. Step-up gearboxes for Proteus compressor drive, David Brown Industries Limited. Steam supply system, Cochran and Company (Annan) Limited, Annan, Scotland. Motors driving Proteus compressors, English Electric Company Limited.

In all, some 111 different firms were involved in the project, and it is therefore not practicable to list completely all the sub-contractors. We give below, therefore, some of the principal sub-contractors.

Hydraulic system for valve operation, Automotive Products Company Limited. Pressure gauges throughout plant, Budenburg Gauge Company. Silencing splitters for exhaust towers, Cementation (Muffelite) Limited. Sound-proof doors, Chatwood-Milner Limited. Cell water-extraction pumps, Drysdale and Company Limited. Fognozl spray equipment for cell cooling, Fire Armour Limited. Temperature controllers, Foster Instrument Company. Main steam control valves, Foxboro-Yoxall, Limited. Swinging stand for test engine, Gordon and Company (Engineering Consultants), Stroud. Explosion venting and suppression systems, Graviner Manufacturing Company Limited. Low-pressure fuel pumps, Harland Engineering Company Limited. Steam ejectors, Hick-Hargreaves and Company. Chart recorders and temperature controllers, Honeywell-Brown and Company Limited. Electrical storage heater, Incandescent Heat Company Limited. Main ducting, Mechans Limited. Heater-transformer, Metropolitan-Vickers Electrical Company Limited. Piping insulation, Newalls Insulation Company Limited. Control panels, New Western Engineering Company. Shadowgraph equipment, Optical Works Limited. High-pressure fuel pumps, Oswald and Ridgeway Limited. Schlieren glasses and cell windows, Pilkington Brothers Limited. Water pressure pumps, Pulsometer Engineering Company Limited. Fuel tanks, Pumps and Equipment Limited. Fuel measuring equipment, Rotameter Manufacturing Company Limited. Air control valves and actuating mechanisms, Rotork Engineering Company Limited. Steam accumulators, Ruths Accumulators Cochran Limited. Fuel throttle valves, Saunders Valves Company Limited. Water-cooled air coolers, Serck Radiators Limited.

"REVOLUTIONARY" NUCLEAR ENGINES FOR UNDERWATER TANKERS

The results of the model tests on underwater hull forms carried out by Saunders-Roe Limited for Mitchell Engineering Limited—described in the 13 December, 1957, issue of ENGINEERING—have confirmed the performance potentialities of the nuclear-powered deep-submarine oil tanker; and pointers to the reasons for Mitchell's interest in such a project have been given recently by the chairman of the company, Mr. F. G. Mitchell.

It appears that Mitchell have under development an entirely new form of prime mover for converting the heat developed by a nuclear reactor into a shaft rotation. This will result in a propulsion unit much more compact and less weighty than any "conventional" form of nuclear engine, and is therefore foreseen as an eminent possibility for marine propulsion. Clues to the type of prime mover are tantalisingly vague. It is neither a turbine nor a reciprocating engine; some reports have described it as employing a rotating reactor core. A prototype is now said to be under construction at Mitchell works, and it will be at least a year before it is ready to go on test. Although Mitchell also envisaged their new development applied to electrical generation, they are not at present receiving co-operation from the Atomic Energy Authority.

Turning now to the hydrodynamic aspects of the submarine tanker: the results of the Saunders-Roe model tests are summarised in an article by Mr. W. A. Crago in the March issue of Mitchell's house journal, *Impulse*. The characteristics of the models tested are given in the table on page 471.

The submerged models were run under predetermined conditions of draught and speed, and their resistance was measured. So that the results could be validly extrapolated to full-scale conditions, a turbulence wire at the front of the model was used to ensure a fully turbulent flow condition. Each model was considered as repre-

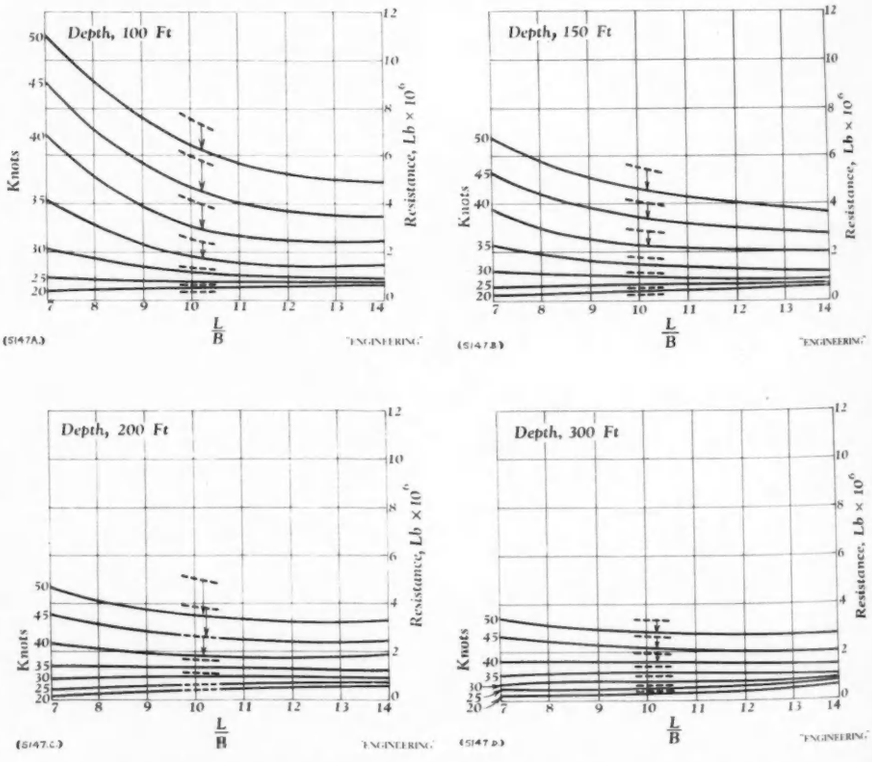


Fig. 1 Variation of hull resistance with the ratio of length to maximum beam at different depths, for hulls where the greatest cross-section is located 0·4 of the length aft.

Model number	1	2	3	4	5	6
L	6	6	6	6	6	6
L/B	7	10	14	10	10	11·3
Section shape	Circular	Circular	Circular	Circular	Circular	Square
a/L per cent	40	40	40	50	60	40

L is the body length, B the maximum beam, and a the distance aft of the nose of the maximum cross-section, all measured in feet.

senting a full-scale vessel of 80,000 tons displacement, and Figs. 1 and 2 were prepared from the test data to show how the resistance of such a craft varies with immersion depth, shape and speed. In the following, and in the graphs L is the body length, B the maximum beam, and a the distance aft of the nose of the maximum cross-section, all measured in feet.

Fig. 1, in which all the hull forms have an a/L value of 40 per cent, demonstrates how the relative importance of the L/B ratio diminishes as submergence is increased. The broken lines represent the square-section vessel, which under some conditions appear to have a slight advantage—but Mr. Crago is unconvinced on this point. In Fig. 2, all the hull forms have an L/B ratio of 10. Again, at considerable depths, the position of maximum thickness has little effect on the resistance characteristics. Both these illustrations show clearly how the resistance is reduced as the depth of submergence increases.

In Fig. 3 is plotted the power required, at various speeds, for an 80,000 ton tanker with an L/B of 10. The power depends not only on the depth of the tanker below the surface, but also upon the total depth of water available. Thus the optimum shape of the craft may be influenced by the depth of water available over the proposed route. For the tanker specified, the power required even for the tanker deeply immersed in deep water appears impractically high; however, Mr. Crago points out, the curves can be scaled down. The point A, for example, corresponds to a 20,000 ton tanker moving at 60 knots and demanding about $5{\cdot}9 \times 10^5$ b.h.p. in water 200 ft deep.

In conjunction with their new power-unit development, Mitchell Engineering Limited believe that these results are sufficiently encouraging to warrant a full-scale design study, and they have retained Saunders-Roe Limited for this task. Mitchell expect this work to take some six months, and when completed, they believe that there will be at least two oil companies sufficiently interested in the project to carry on from there.

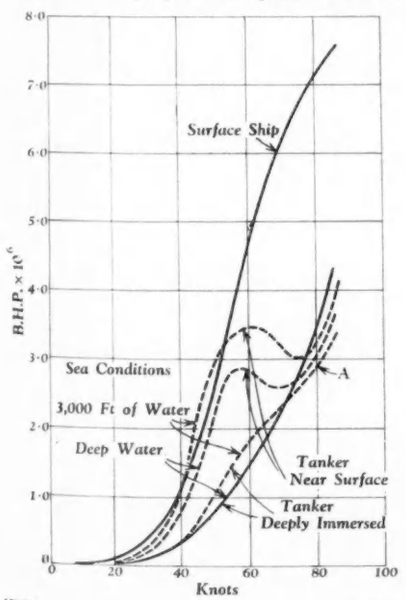


Fig. 3 Horse power/speed curves for different conditions of immersion and total depth of water available, for an 80,000 ton tanker which has a length to maximum ratio of 10.

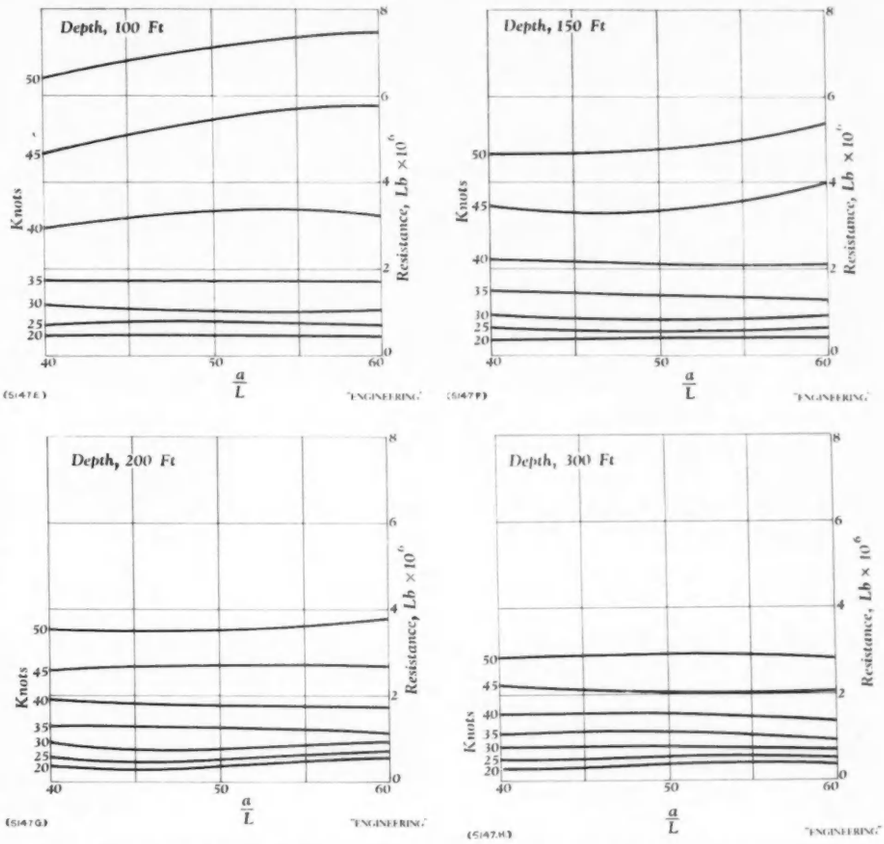


Fig. 2 Variation of hull resistance with a/L value at different depths, for hulls of L/B ratio of 10.

INTERNATIONAL INSTRUMENTS

During the last few years the application of electronics to instrumentation problems has advanced on a very wide front—so wide that no one nation can keep continuously in the forefront of every aspect. In order, therefore, to make available to British research engineers and scientists the latest possibilities in instrumentation, B. and K. Laboratories Limited have made it their task to keep pace with developments throughout the world; and each year they stage an International Instrument Show in London at which a very wide range of electronics is on view.

At this year's show, for instance, some 60 firms from 10 different countries were exhibiting their products. Newer developments from overseas included: from the United States, a new type of humidity-sensing element comprising a conducting plastics material, the electrical resistance of which changes in proportion to the relative humidity (El-tronics Incorporated). From Switzerland came a range of displacement and load transducers based on an inductive measuring system (Vibro-Meter Limited); from Italy, a high-speed etching machine for the rapid automatic production of printed circuits (Lares S.R.L.); from Germany, acoustical instruments for the water engineer, for detecting leaks in mains and service pipes and for locating underground pipes and cables (Dynacord); from Denmark, a stylus-type precision surface roughness meter suitable for use with small bores down to $\frac{1}{4}$ in in diameter and in wires down to 0·02 in diameter (Bruel and Kjaer). There were on view, also, several new developments in spectroscopy and in instruments for chemical analysis; and a wide array of electronic instruments and components for the electronics engineer himself.

INSTRUMENTATION, ELECTRONICS AND AUTOMATION

Nuclear power, space travel, crime detection, automation, the oil industry, and the iron and steel industries to-day all depend on instrumentation, and from this aspect are to be the subject of a conference held in conjunction with the Instruments, Electronics and Automation Exhibition at Olympia, which opens on 16 April and continues until 25 April. The conference programme is as follows.

On Thursday, 17 April, the main speaker is Dr. S. Kaufman, A.E.I. Limited research laboratory, on "Thermo-Nuclear Developments—Sceptre 3"; on Friday, 18 April, Dr. E. B. Dorling, Royal Aircraft Establishment, speaks on "Instrumentation and High Altitude Rockets"; on Monday, 21 April, Mr. L. C. Nickolls, director of the scientific laboratory, Metropolitan Police Headquarters, on "Instruments in Forensic Science"; on Tuesday, 22 April, Dr. A. D. Booth, director of the computation laboratory at Birkbeck College, on "Computers and Numerical Automation"; on Wednesday, 23 April, Mr. S. J. W. Wallis, British Petroleum Company Limited, on "Instrumentation in the Petroleum Industry"; and on Thursday, 24 April, Mr. B. O. Smith, British Iron and Steel Research Association, on "Instrumentation in Iron and Steel." Each session is from 3 to 4.30 p.m., including discussion.

There are also to be two popular evening sessions, on Friday, 18 April, 6-7 p.m., Dr. G. E. R. Deacon, of the National Institute of Oceanography, will summarise "Progress in the International Geophysical Year." On Wednesday, 23 April, 6-7 p.m., there will be a Brains Trust on "Science as a Career," with Freddie Grisewood in the chair; members of the panel will include Dr. W. Abbot, Federation of British Industries; Professor J. Loxham, Department of Aircraft Economics and Production, College of Aeronautics, Cranfield; and Mr. R. E. Burnett, Marconi Instruments Limited.

Metals and Materials

COLD-ROLLED STRIP FROM METAL POWDER

The general concept of the continuous production of strip, or other form of section, from metal powder originated early in the present century. The modern process which has now emerged as a result of research and development consists essentially in the compacting of the powder between a pair of rolls into the form of a continuous strip and thereafter sintering and processing the strip by conventional cold-rolling and annealing operations.

The broad capabilities and limitations of the process are considered from both the technical and the economic points of view in a paper entitled "The Continuous Production of Strip by the Direct Rolling Process," presented at a meeting of the Powder Metallurgy Joint Group of the Iron and Steel Institute at the Institute of Metals, held in London on 19 March. The author, Mr. D. K. Worn of the development and research department of the Mond Nickel Company Limited, Birmingham, states that powder is fed to the compacting rolls, in general arranged horizontally or near-horizontally, via a hopper equipped to meter and control accurately the distribution and flow of material to the roll gap.

The actual compacting operation may be carried out hot or cold. Hot compacting, although offering many advantages, necessitates complex atmosphere control and up till the present cold compacting has received most attention. Provided the raw material possesses the necessary bonding qualities, the compacted green strip is strong enough to be coiled or to be directly passed through a sintering furnace. For economic continuous operation the sintering furnace must have a long hot zone, operating at a temperature as close as possible to the melting point of the material being processed. Employing such temperatures, sintering times as brief as one minute or less are acceptable for materials of conventional types, such as copper, nickel and iron. The mesh-belt type of furnace is satisfactory for strip of relatively low melting point material such as copper, but roller-hearth or walking-beam furnaces may be required for dealing with higher melting point metals, such as iron or nickel.

An actual plant designed for the production of 12 in wide pure-nickel strip from carbonyl nickel powder, comprises a compacting mill having rolls 18 in in diameter with an 18 in face, operating at a surface speed of 5ft per min, and a roller-hearth furnace having an overall length of 40 ft, operating at a temperature of 1,150° C. This unit is designed to produce sintered strip of 0·075 in thickness, to be cold rolled on conventional plant, with five intermediate annealing treatments, to a final product of 0·010 in thickness.

The four main essential characteristics of a metal powder for use in the direct-rolling process are good cold-bonding and sintering properties, adequate purity, freedom from incidental macro-inclusions and uniformity from batch to batch.

The direct-rolling process, Mr. Worn concludes, is technically capable of very wide application, both as an alternative to conventional melting and casting methods, such as for the production of copper and nickel strip, and for the processing of unconventional materials which can be produced only by the powder-metallurgy technique.

With the advent of hydrometallurgical processes for the production of copper powder in bulk, there are reports that the direct-rolling process may compete successfully with conventional methods in the production of copper strip. (By hydrometallurgy is meant the extraction of metals from their ores by leaching methods, in which an aqueous solvent dissolves out the metal without affecting the gangue—Ed. E.) The production of nickel strip also would seem to be a promising application but the production of the more common alloys such as brass, cupro-nickel and the nickel irons, would not appear, in general, to be economically attractive. There is scope, however, for the process in the production of the more unconventional alloys, such as the brittle permanent-magnet alloys, and, in particular, composite materials for atomic energy and other applications. In these instances, the powder metallurgy technique is essential for the production of the material.

REVISION OF BRITISH STANDARDS FOR CEMENT

The high reputation enjoyed by British cement throughout the world has been maintained, ever since 1904, by the specification, British Standard 12, which covers Portland cement (ordinary and rapid-hardening), and virtually all British production has been judged by this Standard, the ninth revision of which has just been completed (the eighth was in 1947). Many detailed amendments have been made to bring the Standard up to date but the main change has consisted in the adoption of a hand-compacted 4 in concrete cube test and the dropping of the tensile test, except for rapid-hardening Portland cement to be used in the manufacture of pre-cast concrete products and for other similar purposes.

The new cube test has been designed primarily for the determination, under standard conditions, of the strength of a cement as represented by compressive strength tests on the concrete cubes, using an aggregate complying with certain specified requirements. In addition, the method is useful to users of cement for determining the quality of their concrete and aggregates and for assessing the adequacy of concrete-mix design.

Hitherto, cement strength tests have been made on mortar, either as briquettes tested in tension or as cubes tested in compression. Both mortar tests required the use of a standard sand from one source only, and the results obtained had to be interpreted carefully in order to assess the value of the cement in concrete.

It is emphasised that the particular advantages of the new standard concrete test are that it permits the use of a wide range of aggregates, within certain specified limits, and that the cement is tested in the form in which it is generally used in practice, so that the results are of more direct value to engineers.

Important developments, other than the introduction of the standard cube test are increases in the strength requirements, improvements in sampling, and the simplification of testing for the setting time and the soundness of the product.

The improved sampling clauses allow a user to sample a consignment of cement in as much detail as he may consider necessary; previously he could obtain only an average sample for a given consignment, however large. The tests for setting times and the soundness of the cement are now much simplified by utilising one standard percentage addition of water for a given sample of cement. This modification has permitted the deletion of a table covering two pages of the earlier edition of the Standard.

Two other Standards for cement have also been completely revised to bring them up-to-date. They are B.S. 146, covering Portland blast-furnace cement, and B.S. 1370, which deals with low-heat Portland cement. Their requirements have now been correlated with those of B.S. 12 and, in these two revised editions also, the tensile test has been replaced.

The three Standards have been revised by a representative committee including nominees from research bodies, civil engineers, architects and surveyors, building interests, Government departments and other large-scale users of cement, and from the cement industry itself.

Copies of the revised Standards can be obtained from the Institution's sales branch, 2 Park Street, London, W.1, the prices of B.S. 12 and B.S. 146 are 7*s*. 6*d*. each post free, and that of B.S. 1370, 8*s*. 6*d*. post free.

SPRAYED ASBESTOS

The spraying of asbestos fibres directly on to a structure or fabric is a process possessing great potentialities. The spraying of Limpet asbestos, as it is called, is carried out on a contract basis by Turners Asbestos Cement Company Limited, Trafford Park, Manchester, 17, and in the method employed, specially treated asbestos fibres are projected simultaneously with a fine water spray from a multi-jet spray gun. Various grades of asbestos fibres are utilised in order to meet certain essential functions and the resultant coating is pliable for two hours, during which time the surface can be flattened or shaped. The material becomes set in about eight hours.

The process, it appears, is now widely employed to combat condensation, provide thermal insulation, give fire resistance and exclude dust. In some types of building, it corrects acoustic effects and reduces noise.

Steelwork, steel beams and columns, concrete structures and floors, all types of walls and roofs, and building fabrics of many kinds may be treated by the Limpet process. Sprayed asbestos coatings may be subsequently decorated in the same manner as asbestos cement.

PLASTICS IN LIGHTING

An exhibition called "Plastics in Lighting" and covering most aspects of industrial, commercial, street, transport and domestic illumination, was staged in London recently by Imperial Chemical Industries Limited, Plastics Division, Welwyn Garden City, Hertfordshire.

Much of the exhibition was devoted to the many and varied uses of Perspex acrylic sheet but there were also examples of the extensive uses now being found for Diakon acrylic powder, both for moulded and extruded components, and Darvic polyvinyl chloride sheet and foil. The 170 fittings on view included items as diverse as a lighthouse beacon and a dental inspection lamp. Several prototype and experimental fittings were also exhibited.

RAPID-HARDENING FILLER

A filler which is reinforced with glass fibre and is stated to be suitable for the mechanical repair of castings, for caulking tanks and concealing sunken screws, for making chemically-resistant jointings and for other applications, has been placed on the market by W. David and Son Limited, 47-49 Caledonian Road, London, N.1. It is claimed to be unaffected by salt, petrol, water and most acids and alkalis and to adhere to all metals and to glass, wood, plastics and concrete. The filler, which is called Isopon, is in the form of paste and after mixing it with a few drops of a hardener, it is applied with a putty knife. The filler, we understand, can be ground, sawn, drilled or tapped ten minutes after application.

Book Reviews

EINSTEIN FOR ELECTRICAL ENGINEERS

Electro-Magnetism and Relativity. By E. G. CULLWICK. *Longmans, Green and Company, Limited, 6 and 7 Clifford Street, London, W.1.* (63*s.*)

Discussion of the electromagnetic phenomena resulting from the motion of material bodies is largely confined to mathematical expositions of the theory of relativity where the purely analytical development is liable to obscure the underlying physics of the situation. Such phenomena have, however, played a significant part in modern physical theory and their omission from courses normally offered to physicists and electrical engineers has tended to perpetuate misleading or erroneous conclusions concerning certain aspects of electromagnetic induction. This book by Professor Cullwick, published with the co-operation of the Institution of Electrical Engineers, stresses the fundamentals of electromagnetic physics from the relativistic point of view and provides a searching examination of the theory of electromagnetic induction.

Part I deals with field components in material media, the first-order magnetic field of an electrostatic system and the first-order electric field of a magnetic source in uniform rectilinear motion, the special theory of relativity, Maxwell's equations and their relativistic transformation and the relativistic form of the component field theory. Retention of the pole concept in magnetised bodies is shown to be capable of providing a consistent first-order theory for velocities of translation small in comparison with the velocity of light, without recourse to relativistic consideration. The correlation of the general field transformations with the relativistic treatment of each field component reveals the precise contribution of each field source and enables exact solutions of practical problems to be obtained by straightforward physical reasoning and, in fact, many such problems are worked out from first principles. There is a detailed discussion of the experiments of Röntgen and Eichenwald designed to show that a convection current (due to the motion of an electric charge) has the same effect on magnets as a conduction current; critical consideration is also given here, and in an appendix, to the so-called " clock paradox," still a topic of current controversy.

Part II deals with the laws of electromagnetic induction and begins with a careful examination of the meaning of the terms " induced electromotive force " and " potential difference." Particular attention is directed to problems in which pre-relativistic theory proves inadequate, such as induction in a rotating cylinder which is both an insulator and magnetic, and the velocity of propagation of an electromagnetic wave in a moving dielectric which is magnetic. The complex subject of electromagnetic induction in conducting fluids is dealt with briefly and its geophysical implications outlined.

Part III is concerned with the relativistic theory of second order e.m.f.'s in moving circuits and Part IV with a study of electromagnetic energy and momentum. Of special interest in this final section are the comments on the electron inertia hypothesis and the new light it sheds on the theory of the induction of currents in superconductors though, admittedly, a complete theory must involve an understanding of quantum electrodynamics.

The latter part of the book is addressed to advanced students but in the first part Professor Cullwick has endeavoured to " provide the basis for a first order and elementary theory which can be taught to undergraduate students of physics and electrical engineering without recourse to the full theory of relativity." That this attempt, given the requisite attention and effort on their part, does not appear over ambitious can be attributed to the care he has taken to present his arguments so clearly and logically in terms familiar to them, without losing sight of the phenomena and without skipping any of the relevant steps. The reward of their effort will be a deeper understanding of some of the fundamental concepts in modern physics.

TECHNICAL TRANSLATION

Aslibians and professional translators recently held, under the combined chairmanships of Dr. J. E. Holmstrom, of Unesco, and Mr. E. B. Uvarov, a consultant, a one-day conference on " Scientific and Technical Translation."

Papers were read by Dr. A. L. Mackay, of Birkbeck College, on the " Organisation and Availability of Technical Translation"; Mr. Felix Liebesny, patents information officer of the Mond Nickel Company, on " The Economics of Translation "; and, after an excellent lunch, Mr. G. A. Readett, head of the translation section of the National Coal Board, spoke. The conference arose out of the Unesco Report " Scientific and Technical Translating and other Aspects of the Language Problem," of which a new edition can be had from H.M. Stationery Office.

Much of the talk was of facts already familiar to those concerned with translation and little was said that is likely to resolve present difficulties. The Russian bear was ever-present in the background and it was surprising, to the writer at any rate, that nobody suggested that Russian should be a required language in our schools. Several hints were dropped that a universal language might be adopted for scientific writing and Dr. Mackay pointed out that English is the most popular means of expression at the moment. He emphasised a fact that is already well known, namely, that there is too much duplication.

Mr. Liebesny's was an admirable paper and it was evident that he had gone to much trouble in marshalling his figures. He cited eight methods of translation, such as dictation on to tape, direct transcription on a typewriter, oral translation and so forth. Of these, from the point of view of man-hours, material, etc., he opined that tape was the most economic. As a patents man he told of the difficulties of such translation with its necessity to satisfy the legal mind, the insistence on the inclusion of every word and expression and all the other paraphernalia associated with jargon. One very interesting point he made was an assessment of costs when using a computer for translation work. Giving some typical figures he worked out that with upkeep, replacements, initial cost and the rest, a computer would cost £7,000 per annum, producing 1,000 million words (I hope I have my noughts right). This is equivalent to £250,000 spent on human translators. His paper was illustrated by charts that were no doubt enlightening but quite illegible from the body of the hall.

Mr. Readett confused opinion by his description of how he built up his team of translators. He took linguistic experts and waited for them to pick up the technicalities. This is quite contrary to general opinion but the speaker has obviously made it work completely successfully. Every help is given by lectures, visits and, of course, the ordinary course of their translation work. The discussion followed the usual pattern. Nearly every speaker had an axe to grind but these axes were blunter than usual. With a fair sprinkling of commercial translators in the audience it was inevitable that rates for the job should come into it. And it did.

I gathered that Aslib is to organise yet another couple of conferences, one to make Russian translations available in this country and the other to be in association with the Institute of Linguists to last for three days I believe.

On the Shelf

By Frank H. Smith

The work of the Shell Film Unit and its high standard are well known and the first two parts of its trilogy on supersonic flight will cause no disappointment. Part 1, entitled " Approaching the Speed of Sound," has been ready for some time, and Part 2, " High Speed Flight," is now available from the Petroleum Films Bureau, 29 New Bond Street, London, W.1. These films, by means of cartoon, diagram and straight photography, are intended for a non-specialist audience and Part 2 deals with the transonic range, i.e., from below to above the speed of sound. The various phenomena encountered by pilots " crashing the sound barrier " are explained as are the difficulties encountered by aerodynamicists and structural engineers. The film makes an interesting use of the principles of Schlieren photography. In an accompanying descriptive pamphlet Shell say that the film " is for use by pilots transferring to jets, by air cadets and by members of air forces generally. It will provide background information for airline staffs. It should also be of interest to all air-minded people."

It is quite surprising, the lengths " foreigners " go to make their publications as helpful as possible. For instance, *L'Aerotecnica* is produced, naturally enough, in the native language of Italian but this disadvantage to non-Italian readers is largely offset by their including at the end of the last two numbers (and presumably in future) a tear-out sheet composed of 5 in by 3 in title-abstract cards in English. One wonders if the same is done for those issues that are sent to Germany, France, Scandinavia and the rest. If so, the publishers of the journal go to much trouble to provide a useful service.

Some idea of the extent to which documentation is becoming a science is gained by the fact that Interscience announce the publication of volumes 1 and 2 in a series *Advances in Documentation and Library Science*. The titles are *Progress Report in Chemical Literature Retrieval* (Peakes, Kent and Perry at 4.75 dol.) and *Information Systems in Documentation* (Shera, Kent and Perry. 12 dol.).

Little does my reader realise the trouble I go to to help him. For instance, I have a journal here which I have not seen before called *Aplikace Matematiky* from Prague. Now Czech is not one of my accomplishments and I do not know, therefore, from Svazek 3 Cislo 1 whether it is Vol 1 No. 3 or Vol. 3 No. 1 but I think it is the latter. But what really matters is, where is it published? I can only suggest what, to me, looks like an address: Matematicky ustav Ceskoslovenske akademie, Praha II Zitna 25. I hope that it is not a telephone number and that the Slovak postal authorities can solve it without the accompanying accents.

The fathers among you may like to know of a Heinemann series of paperbacks called the New Windmill Series. These are specially for children and the estimated age range is given for each book in the list. Prices are around the 5*s.* mark. Heinemann's address is 99 Great Russell Street, London, W.C.1, and I have no doubt they will be pleased to forward their advertisement material.

Constable, 10 Orange Street, London, W.C.2, have a horrible pun on the front of their spring list in the shape of three policemen dashing out of a door that has a police station lamp over it but which, strangely enough, bears the legend " Orange St. Constables: Constable Station." It would be interesting to know if the faces of these characters bear any resemblance to the firm's staff. Among the technical books announced is *Uplift in Gravity Dams*, by Leliavsky; *Electricity in Aircraft*, by Spreadbury, and *Studies of the Comparative Ethology of Digger Wasps of the Genus Bembix*, by Evans. These are only three of Constable's titles which I have selected to show the breadth of their interests.

Design

WHICH SHOULD TURN—WHEEL OR AXLE?

By J. T. Emmerton

Modern wheeled transport may be classified in two main groups: (i) vehicles with loose wheels on fixed axles, and (ii) those with fixed wheels on revolving axles. The former mounting is used for the majority of road vehicles with the bearings carried in the wheel hubs, while the latter are predominantly rail vehicles, the axles of which revolve in axleboxes which may be placed inside or outside in relation to the fixed wheels.

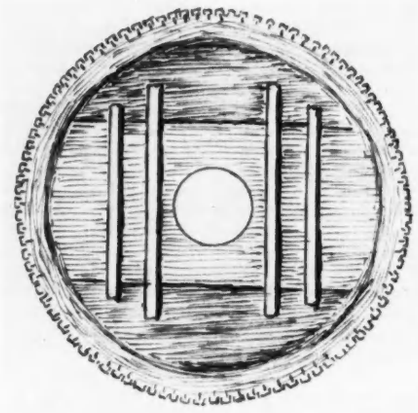


Fig. 1 At Ur, 4,000 years ago, built-up loose wheels, studded with copper nails, were used.

Fig. 2 Egyptian chariots of 1400 B.C. had loose wheels. One was found in Tutankhamen's tomb. Contemporary cars, however, had solid wheels.

This article is an attempt to trace the origins of the two practices. The evidence of the earliest times is very meagre, but there can be found a fairly well authenticated record in pictorial form in the case of the earliest examples, followed by surviving remains of wheels and then, later, by descriptive writings.

The wheel is considered on reasonably well established evidence[1] to have been invented in Sumer (*c.* 3500 B.C.) whence its use spread into Middle Asia, Northern Syria, India, Egypt, Greece, Italy, Central and Northern Europe, reaching Britain about 500 B.C. The earliest pictorial representations are found on tablets and vases (*c.* 3100 B.C.).[2] The earliest actual wheels discovered[3] were built-up constructions of tripartite form (Fig. 1), similar to the chariot wheels depicted by the Ur Mosaic Standard (*c.* 2600 B.C.).

These very earliest representations and remains evidence in general some form of peg or linch pin to retain the wheel, and the holes for the axle ends in the first actual wheels found were circular. Excavations in Mesopotamia[4] have revealed copper bolts for the attachment of a wagon frame either to an axlebox or to the axletree, and a copper model of a chariot of the third millenium which has its axle free to revolve in a pair of metal loops on its base. Copper models of *c.* 2000 B.C., from Northern Syria, had a rectangular axle attached by a central rivet to the body. The axle ends were round and linch pins were fitted outside the wheels, presumably indicating loose wheels. Other copper models of the Bronze Age from India had holes in the cross bars of the main base through which two pairs of pegs extended below to fork the single axle. The wheels were retained by linch pins.

The evidence in favour of either fixed or free-running wheel throughout this period is inconclusive. Even with an axle held between dependent pegs, as in the model from India, rotation of the wheel independent of the axle, even if free on the axle end, would be determined by the relative values of friction at the bearing positions. It is possible, therefore, that the wheels ran free. Assyrian bas-reliefs of *c.* 750 B.C. show soldiers swimming rivers carrying dismantled chariot parts, and this need to cross rivers, swamps or difficult terrain involving porterage may have dictated a readily displaceable mounting of the body on the axle, without necessarily entailing a fixed wheel.

Authorities state that the wheel reached Egypt from Asia Minor about 1600 B.C., and Greece perhaps a little later. In both countries by this period wheels—for chariots at least—had advanced to a spoked construction. This is evidenced by decorations on Greek vases, Egyptian wall paintings, and deposits of complete vehicles in Egyptian tombs, which have provided full knowledge of the wheel mounting. In the tomb of Tutankhamen (*c.* 1400 B.C.) were four chariots having single axles with two spoked wheels running free on the axle ends, and the basket or body resting directly on the axle. A very similar form is shown in a wall painting (Fig. 2) attributed to *c.* 1400 B.C. A much cruder construction is to be seen in the Philistine bullock carts of *c.* 1100 B.C. but here also the wheels are free running and retained by a linch pin.

The chariot wheel with its elaborate and light construction would seem to have been a particular development adapted to achieve speed and manoeuvrability, while, from the evidence of rock paintings and inscriptions, concurrently there existed a cruder and more robust form for rough usage. Translations by Sir Henry Rawlinson of Assyrian inscriptions of *c.* 1100 B.C. read: "I traversed . . . the easy parts in my chariots and the difficult parts in wagons of iron. . . . As the steep mountains . . . were impracticable to the passage of my chariots I placed my chariots in wagons. . . . I betook myself to carts of iron in order to overcome the rough mountains."

The Greeks and the Romans, who may have derived their knowledge of the wheel from a common source, used both chariots and wagons. Vase decorations and marbles from Greece provide evidence of both revolving and fixed wheels.

The Romans with their extensive road systems made great use of wheeled vehicles. The emperors Herodotus (450 B.C.) and Camilius (350 B.C.) are each recorded as using chariots. Plutarch remarks that the Roman Consul, Emilius, in 170 B.C., had 750 wagons in his triumphal procession. An ox wagon with solid wheels secured by square ends to a revolving axle is carved on the Antonine Column (A.D. 174), and the Trajan Column (A.D. 113) also shows a modelled wagon.

Many varying types of Roman vehicles are described by Beckmann, Straus and Haddon[5] employing both loose and fixed wheels. The *plaustrum*—a heavy two-wheeled cart—and the *p. majus*—a four-wheeled type—ran on broad spokeless wheels fastened to an axle which revolved within wooden rings secured to the underside of the main platform. Roman chariots had the usual revolving wheel.

Both chariots and carts are known to have been used in Britain in the Iron Age, and the Romans on reaching there in 55 B.C. found themselves opposed by a chariot (*essedum*) superior to their own. This in common with other chariots had the revolving wheel. The Roman baggage wagon, believed to have been derived from the

Figs. 3 and 4 The Luttrell Psalter shows a Fourteenth Century cart with loose wheels. In contrast, the carriage for ladies was a massive affair, but also with loose wheels. (British Museum).

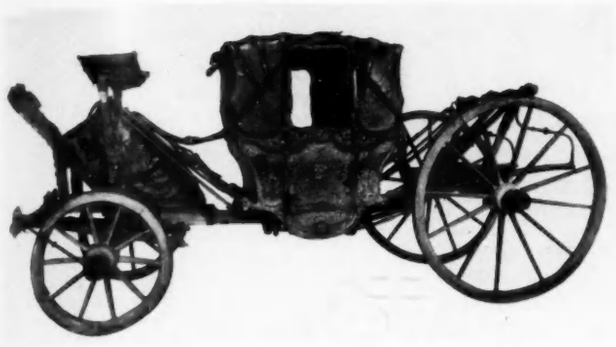


Fig. 5 Thomas Baskerville's coach of 1698 was one of the first in England. It, too, had loose wheels. (Corporation of Nottingham.)

Greek wagons, was introduced here, and it is often stated[6] that it was the cumbrous character of these with their fixed wheels, often up to 1 ft in width and the absence of a swivelling front axle, that provided a compelling reason for the direct straight line feature of the Roman roads.

For some centuries following the departure from Britain of the Romans (A.D. 410) there was no development here of wheeled transport. Such transport as was necessary was largely by packhorse or rude carts drawn by oxen or horses. There was in consequence no incentive to maintain the road system left by the Romans, and the serious state of decay into which it fell is shown by the descriptions of the appalling conditions as revealed in the publications of Sixteenth Century writers.[7] Throughout a period extending from the Fifth to the Seventeenth Century there is very little material available pertinent to the present examination.

Pack and wagon trains of traders and merchants comprised the bulk of the traffic, saddle horses being used for the greater part of personal travel. Carriages were, however, few, and very crude in design. The general character of contemporary vehicles can be seen from the Luttrell Psalter[8] (1340) which depicts a two-wheeled agricultural cart (Fig. 3) and a four-wheeled covered carriage for ladies drawn by a team of horses (Fig. 4). The latter is seen as a springless wagon with a tilt.

The first coach is said to have been built in Hungary, and in 1565 a state coach was presented to Queen Elizabeth, an extensively decorated springless vehicle. This was preceded about the middle of the century by stage or long wagons, lumbering springless four-wheelers with large broad tread wheels drawn at about 2 to 4 m.p.h. by up to six horses. Regular systems of such wagons were operating in 1637 and continued in use up to the Eighteenth Century. The stage coach came into use about 1640 commencing services between some of the principal towns, Edinburgh and Glasgow 1678, London to York 1706, and London to Edinburgh 1712.

Much of the evidence in regard to the wheel mounting up to the middle of the Eighteenth Century is confusing, but it points largely to the use of the loose wheel. This fitting is implied by the linch pins indicated in the Luttrell Psalter. A carved and painted coach of 1698 (Fig. 5) has loose wheels with bearings of hardwood and wooden linch pins. The British Royal State Coach (1761), that of the Lord Mayor of London (1757), and the Darnley Coach (*c.* 1720), all have loose wheels. Captain Burt, writing[9] to London from the north of Scotland, refers, however, to the axletree going round with the wheels (1730). Irish engravings of 1791 show carts with the wheels and axle solidly joined together and revolving as one piece. Mr. R. H. Lane[10] illustrates an Irish cart with a similar mounting.

W. Bridges Adams, writing in 1837,[11] remarks that in very early designs the axletree revolved in gudgeons beneath the vehicle. It is probable that Adams is referring to a theoretical stage of development rather than to actual examples, as little support can be found for his statement.

The evidence is strongly in the opposite direction. Hilaire Belloc[12] in *The Highway and Its Vehicles* (1926), states that "the fixed axle mounting imposes itself." He discusses its advantages in regard to lubrication, strength and cost, and indicates that in general the fixed axle was predominant. His book contains a wealth of illustrations of vehicles, both English and Continental, from the Eleventh to the Eighteenth Century, and without exception these appear to have loose wheels. He admits some few examples of revolving axles, but only as being exceptional.

British patent specifications of the early Seventeenth Century in respect of such vehicles as charriotts, chaires, coaches, wagons, waynes, carts and litters refer more particularly to loose wheels. No. 31 of 1625, granted to Edward Knappe, describes "Divers newe wayes and meanes by which coaches, caroaches, carts and other carriages maie be made to last and contynue longer to goe with more ease . . . that is to saie by makinge the axeltrees of iron, brasse or steele either of one length fixed to one wheel and boxed in the other, or of two lengths fixed severally in either wheele and boxed vnder the bodie of the carriage . . . " The reference here to boxes under the vehicle concerns a claim whereby the wheels could be moved inwards or outwards to vary track width. No. 143 of 1664 to Abraham Hill applied to a chaire set on shafts or perches resting solidly on the fixed axles of 4 or 2-wheeled vehicles. No. 1389, to Daniel Hancock in 1711, described a method of making iron boxes for the wheels. Garnett in his roller bearing specification of 1787 described its use with a revolving axle under a wagon or other carriage, and also in the nave of a loose wheel.

Reliable evidence is available, however, of the practice adopted for the wheels of the mail coaches, which commenced service in 1784. William Felton[13], a practical coachbuilder, published his *Treatise on Coaches* in 1796. This gave descriptions and illustrations of the various types of axles with loose wheels and of the several kinds of bodies he supplied. Fixed axles of the early Eighteenth Century had tapered ends which were housed in a pipe box constructed by welding iron plates together to form a broad projecting seam to locate it in the nave. A hollow was provided inside to hold grease. The inside end of the axle arm was left square, and a wide iron washer shrunken on against which the box operated. An iron collar at the outer end retained the wheel, a linch pin being driven through the arm. Later the inside rubbing washer was welded in place, and a screwed nut adopted with the linch pin. Lubrication was needed about every two or three days, or 60 to 70 miles.

This axle was superseded by the "mail" axle having a cylindrical arm (Fig. 6). A circular revolving flange plate was fitted behind the rub-

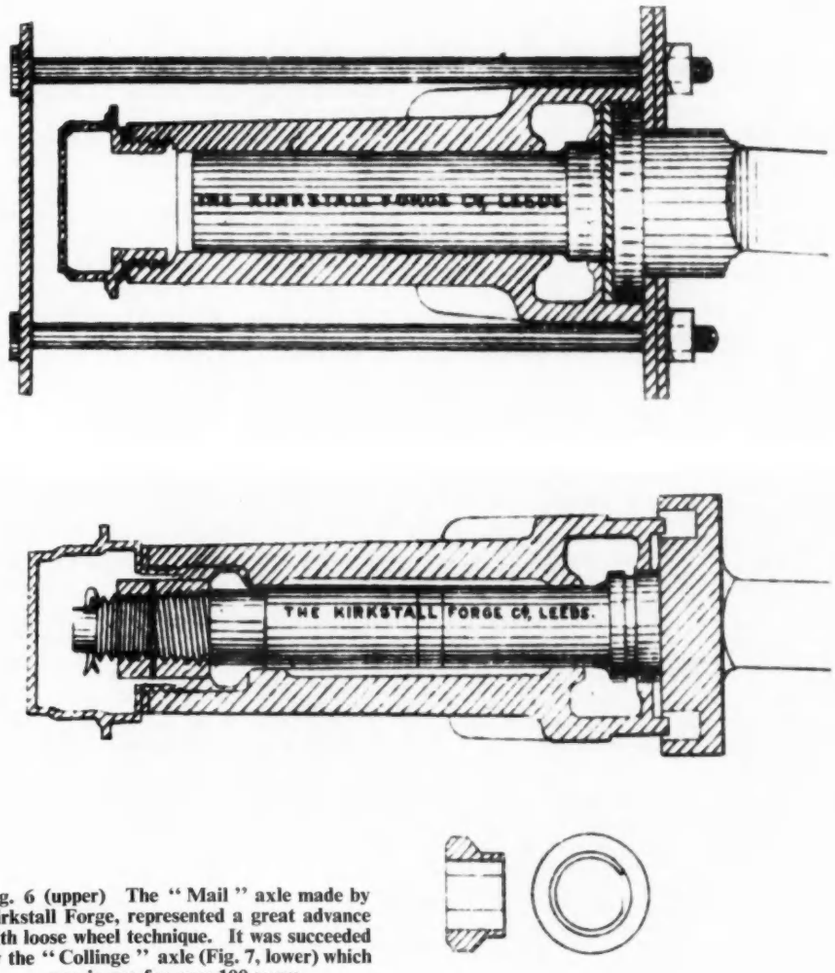


Fig. 6 (upper) The "Mail" axle made by Kirkstall Forge, represented a great advance with loose wheel technique. It was succeeded by the "Collinge" axle (Fig. 7, lower) which was in use for over 100 years.

Continuing Design

bing collar to surround the circular enlargement of the axle, and the front end was closed by a plate. The two plates were connected by long screw bolts passing through holes in the nave, space being left between the front plate and the end of the axle arm to serve as a lubricant reservoir. The mail axle was in turn replaced by the Collinge axle (Fig. 7), British Patents Nos. 1626 of 1787 and 1899 of 1792. In the latter, Collinge provided for large recesses at each end of the box to form lubricant chambers. Collinge was granted a further improvement patent in 1811. Wheel boxes as exemplified in the Collinge axle, but embodying many later improvements, continued in use until well into the present century.

It is seen, therefore, that during the whole of the period from the Seventeenth Century, when the change in the attitude to travel instituted a big development in vehicular traffic, to modern times the loose wheel with its facility of turning, simplified axle mounting, advantages in lubrication, and its greater strength held sway, with only a few exceptions, for common road vehicles of all types.

During the period in which the use of the coach for common roads was extending, a separate usage of the wheel, which was to have a far-reaching effect on transport, was taking place. This development was in relation to mining and rail vehicles and it is documented by early German publications, which however provide but scanty information upon wheel mounting practice.

Some German sources claim that rails were in use in the Harz mines in the Twelfth Century, but it is not until the Sixteenth Century that unfitting the rails." Fortunately, Gabriel Jaa of the Royal Academy of Science, Paris, in his *Voyages Metallurgiques* (1765) describing a visit to the Durham Tanfield Moor wagonway illustrates one of the Newcastle coal wagons (Fig. 9). These were unsprung with wheels of solid wood secured with a linch pin, but in some wagons the larger front wheels were of cast iron and spoked. The *London Magazine* of 1764 commenting upon the Newcastle coal wagons, describes the fore wheels as cast metal and the hind wheels as wood, adding that the " extremities of the axles are fixed in the wheels and turn round." Bailey and Culley, in *A General View of the Agriculture of the County of Northumberland* (1797), remark " coals are conveyed . . . in a peculiar kind of carriage " having " four small wheels about 34 inches diameter fixed to the axle with which they turn." " This kind of conveyance has been used here upwards of 120 years." The Victoria History of Shropshire in reference to the Coalbrookdale wagonway built in 1750 records that the son of the first Abraham Darby " retained the accustomed size of the waggons and adopted for them a cast-iron wheel having an inside flange and a cast-iron axletree on to which the wheel was wedged." John Curr, in his *Coal Viewer* of 1797, gives detailed information and drawings for the manufacture of wheels and axles, and states " If the wheel will just turn round upon the axletree it is quite sufficient," and Nicholas Wood, in his *Treatise on Railways* (1825), records " many of the carriages used upon the plate rails had wheels loose upon the axles."

From these extracts and other contemporary writers it is clear that on the wagonways at this period there was no hard and fast practice in regard to wheel mounting, although a trend to the adoption of the fixed wheel is noticeable. The reason for this is probably to be found in overrunning. Galloway[17] and others have described the many instances of wagons running amok and becoming derailed, and the introduction of the convoy (brake) would in the case of loose wheels have aggravated the trouble. An interesting letter[18] in this regard was written in 1754 from one, William Brown, to Carlisle Spedding at Whitehaven: " As to the Runns in our Waggonways . . . we find that our Convoys will not hold a Large Waggon when the Runns is so much Notwithstanding we lay Ashes and sometimes Cynders to Ruffen the Railes. . . . I think there is no Deficulty at all in getting your wg. Down . . . the Hard thing upon you will be your mettle wheels some of which indead is in our Country but these is used as fore wheels for we allways have wood for the Hind wheels which with a Convoy well Breasted will totally Stop or Trail the Hind wheels. We have lately contrived what we call a Long Convoy . . . so That now can trail all the 4 wheels."

The loose wheel secured by a linch pin would obviously soon allow a large amount of rock in the bearing of that time, which would have increased the risk of derailment. Nicholson Wood remarks upon this " it is necessary that no vibration of the wheels should exist, otherwise the liability to get off the rails would be greatly increased. In all bearings similar to those used on common roads some vibration exists, especially when they are a little worn, and the least vibration is injurious."

The changing practices seem to point strongly to attempts to prevent a loose running wheel from advancing relatively to the other and causing derailment, a risk probably increased by the lower frictional resistance of iron wheels firstly on wood rails and later on iron rails. Wood's comments have also to be kept in mind. These features seem to provide the reason for the more prevalent adoption of both wheels fixed upon a revolving axle.

Although there is little detail knowledge available of either the wheel bearing or of the axle bearing of the coal wagon during its earliest years there is fortunately a very full description of a quarry wagon contained in a publication of 1734.[19] In this case cast-iron wheels were fitted to a 3 in diameter axle of iron having one end square and its wheel fixed, and the other end round on which the wheel could rotate. The square ends of the respective axles were on opposite sides of the wagon. The axle was attached to the frame by iron brackets in which there was a semi-circular copper bearing.

D. K. Clark[20] in 1855 remarks that " the first axleboxes used under coal waggons without springs were of the simplest kind." " They were, in fact, semi-circular bearings of cast iron bolted to the waggon frame, having sides or jaws extending downwards and joined under the axle by a plate or bolt to prevent the axle from dropping out." (Fig. 10.)

At the close of the Eighteenth Century, therefore, the two practices are to be found on the 477 wagonways, with a definite trend to the fixed wheel.

The first quarter of the new century saw the invention of the steam engine, and the building of locomotives for haulage on the colliery railways, followed by the opening of the Stockton and Darlington Railway and soon after the Liverpool and Manchester. By that time, fixed wheels had become almost standard practice, and many contemporary publications and patent specifications refer to the mountings. Nicholas Wood in the first edition (1825) records that axles were universally made of wrought iron, square at the ends to fit the square hole through the nave of the wheel. He further describes the axle mounting of colliery wagons: " Upon the frame is fixed a chair which rests upon the axle, the latter being turned smooth to reduce the friction as much as possible. Upon the side of

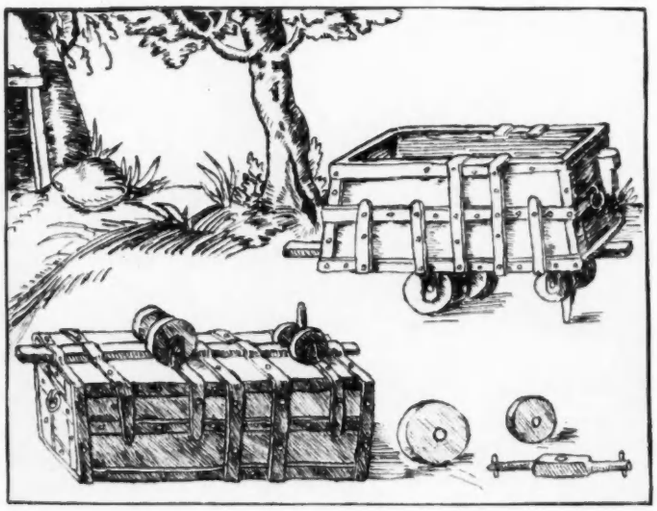


Fig. 8 (left) The earliest mine trucks had loose wheels, as shown by this example of about 1550.

Fig. 9 (above) Newcastle coal wagons of 1765 had fixed wheels and revolving axles. The rear pair were of wood to suit the braking system.

impeachable evidence is forthcoming. Hazelberg's publication[14] of 1519-1530 illustrates a four-wheel truck on rails, and the 1550 edition of *Cosmographie Universalis* shows an iron wheeled rail truck, but in neither instance is any detail given of the wheel practice. Agricola in *De Re Metallica* (1556) has, however, a clear illustration of a mine truck in which the wooden wheels ran freely on the iron axle ends (Fig. 8). A Transylvanian wagon with solid flanged wheels of wood, loose on the axle ends, attributed to the Sixteenth Century, is exhibited in the Berlin Verkehrs-und Baumuseum.

It is generally accepted that the rail track wagonways were introduced into England by miners who had been brought here from Germany during Elizabethan times.[15] The existence in Nottinghamshire of rails for wagons towards the end of the Sixteenth Century is documented,[16] and from that time forward many publications refer to the wagons used in this country.

William Gray's *Chorographia* (1649) records " waggons conveying coal to the staithes at Newcastle." Another publication describes the vehicles as " bulky carts made with four rowlets

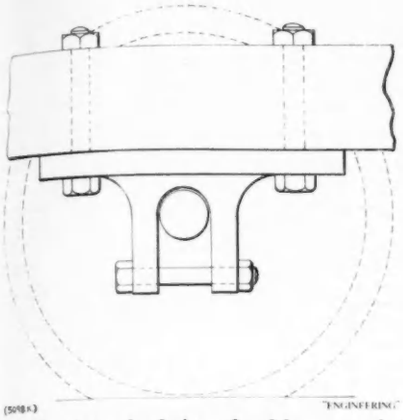


Fig. 10. An early design of axlebox was that described by D. K. Clark.

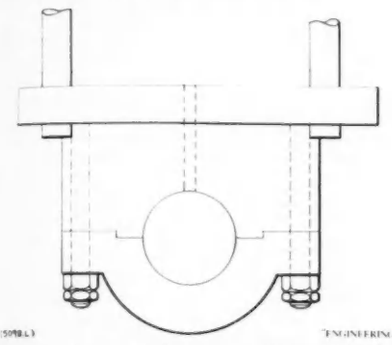


Fig. 11 "A chair for a revolving axle" described by Nicholas Wood had a bottom cap to exclude dirt and a drilling for lubrication.

this chair a projection is cast extending beyond the side of the same and the carriage, which projection by rubbing against the face flange in the nave of the wheel prevents the carriage from coming in contact with it and being kept well greased or oiled reduced the friction when by one side of the road being lower than the other the body of the carriage is thrown to one side. These chairs have been made successively of wrought iron, brass and cast iron."

In his 1838 edition, Wood illustrates (Fig. 11) an improved form of coal wagon in which the inside mounted bearings consisted " of a cast or wrought iron chair secured to the frame by bolts with a semi-circular bearing for the axle." Subsequently the exposed lower half of the bearing against which " the dust of the railroad operated very injuriously " was closed by a cap secured by the bolts fixing the chair to the frame. Oil was applied to the axle through a hole in the chair. Chairs, or bearings of this general character, are illustrated by the drawings of Stephenson and Losh, British Patent No. 4067 of 1816, and William Chapman's Patent No. 5540 of 1826.

Other patents of the period having a bearing on the general subject are Nos. 5325 of 1826 and 6092 of 1831 both granted to Robert Stephenson. In the earlier one he remarks " . . . whenever the railways deviate from a straight line, the opposite wheels of the carriage must necessarily pass over different extents of surface . . . To accommodate therefore the different velocities with which the opposite wheels must move when running upon curved parts of the line or rail the wheels have been frequently attached loosely upon fixed axles, but this has allowed of some little freedom or play." " The most convenient mode, therefore, has been found to be fixing the running wheels of the carriages upon revolving axles."

The 1831 specification reads: " In the carriages now used upon the Manchester and Liverpool Railway each pair of wheels are fixed fast on the two opposite ends of a long solid axis which revolves with the wheels." " For travelling on edge railways the wheels on the opposite sides of the carriage require to be firmly united, so that they will turn round together in pairs, in order to prevent one wheel from advancing either faster or slower along one rail than the other wheel . . . hence the mode above stated has been introduced, that of fixing each pair of wheels upon a solid axis which turns round with them and compels them both to go together."

From the above it is seen that at almost every period of the five thousand years of history of the wheel the two practices have existed, and the choice between them has been determined by practical considerations.

The loose wheel of light construction for chariotry of pre-Christian days resulted from the requirements of speed and easy turning on comparatively easy terrain, while for reasons of cost and replacement a fixed and heavier wheel was often adopted for slow and arduous duties.

In comparatively recent times the revolving axle is found in remote areas, while the fixed axle predominates in general use.

Not until the Eighteenth Century, with the introduction of braking, does the revolving axle become adopted as a defined practice on the wagonways as a deterrent against derailment.

The early Nineteenth Century with its division of public transport into road and rail services marks the absolute separation of the two forms, when for the purpose so clearly defined in patent literature the fixed wheel became standard practice on railways.

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REFUELLING VALIANTS IN FLIGHT

The " probe and drogue " refuelling technique for increasing the range of aircraft has been applied to the Valiant bomber. The makers, Vickers-Armstrongs (Aircraft) Limited, Weybridge, have carried out the conversion in conjunction with the manufacturers of the refuelling equipment, Flight Refuelling Limited, Tarrant Rushton, near Blandford.

The principal operations involved in converting a Valiant to the tanker role are as follows: installing in the bomb-bay a fuel tank complete with turbine pump and piping; fitting turbine pumps in the fuselage tank cells; installing in the bomb-bay a hose drum unit, piping and fuel pump; fitting a bomb-bay fairing, wing stalks and underwing tanks; and installing the fuel-transfer control panel in the cockpit.

The use of Valiant jet tankers significantly improves the scope of flight refuelling, as contacts may be made at high altitudes and speeds. In the past, with piston-engined tankers, the jet receiver aircraft was compelled to reduce operating height and speed to establish contact. Fuel-flow transfer rate is high, the tanker's equipment being designed to meet the normal pressure refuelling requirements which are found in military aircraft.

At the start of the operation the tanker Valiant trails the refuelling hose to its full length of some 90 ft. To resist the air loads on the drogue an electric motor is geared to the hose drum via a fluid coupling, and tends to wind the hose back on to the drum. The drogue, however, gives a set load for a given airspeed. This load is in excess of the " wind-in " load of the hose unit, and consequently the hose trails to its full length. If the drag is reduced, the motor winds in the hose on the drum and any slack is taken up.

The receiver Valiant flies the probe into the drogue at a relative speed of 3 to 4 knots and proceeds to close on the tanker. The surplus hose is then being wound back on to the hose drum. When the receiver is in the refuelling position, which will be indicated on the tanker control panel, the tanker operator switches on the fuel valve. Provision is made for de-icing the probe before contact and for earthing the difference of electrical potential between the two aircraft on initial contact.

After completion of refuelling, the receiver aircraft falls back to the limit stop at full hose extension. At this point the load on three spring-loaded toggle arms, which close on to the refuelling probe on contact, will be increased until the break away load is reached. The refuelling cycle is then complete.

For driving the fuel booster pumps, air turbines were chosen, using air tapped from the engine compressor. Tappings from each engine, already linked to a common feed for pressurisation and de-icing, have now been extended to cater for fuel transfer operations.

Production

AUTOMATIC CONTROL AND INSPECTION

Below, we give brief extracts from two of the papers presented at the Conference on Technology of Engineering Manufacture, arranged by the Institution of Mechanical Engineers, from 25 to 27 March. The first, by Mr. D. T. N. Williamson, of Ferranti Limited, was entitled "Automatic Control of Machine Tools"; the second, by Mr. H. J. Elton, of the Ministry of Supply Inspectorate, described a "Three-Dimensional Tape-Controlled Inspection System."

MACHINE TOOL CONTROL

During the last eight years automatic electronic control techniques have been applied to machine tools, first to the simpler general-purpose types and now increasingly to the more specialised ones. The first attempts took the form of copy-turning and copy-milling machines, but for general milling the problem is far from simple and no fully automatic copy miller has made its appearance.

In hand control, time is lost because the operator cannot transfer the information fast enough to the machine controls, and therefore the problem is not simply one of machine control but also of ensuring that the transfer of information from the designer to the machine is simplified and speeded up. There is wide scope for the direct generation of control data at the design stage, especially where the article is a formalised one such as a turbine blade or an aerofoil section.

The simplest systems are those that will position an object, for example the table of a jig-boring machine, either from punched tape or punched cards, or more simply from dial settings. When the process is repetitive the percentage of time spent in positioning becomes greater and the use of controls more economic. A slightly increased complexity of control gives rise to a system whereby the table does not travel in a random manner from point to point but follows a straight line, working from a linear interpolating system. The next step is to use a quadratic interpolation which reduces the number of points to be calculated for the same accuracy of work. It is, however, a disadvantage that undesirable sharp changes in slope may occur where two quadratic sections intersect. A better method, therefore, employs digital techniques to make a curve generator that will generate a true curve in real time. Such a generator could be included with the control unit beside the machine tool and fed with block information on punched or magnetic tape.

For other than simple work consisting of two-dimensional interpolation, the calculations required can be responsible for the major operating cost of a numerical control system. The amount of calculation is less for true-path controls. These calculations can be done by hand or with a digital computer. On an average the use of a computer will reduce the number of planners necessary to operate a system by a factor of ten. This is of overwhelming importance when the number of components to be made is less than ten. The choice of a central computer service or a special-purpose digital computer must depend on the economics of the case.

In view of the complexity of the electronic apparatus involved as compared with that normally met with in industry, a new concept of reliability should be encouraged. This might be expressed as "trustworthiness" and defined as the inability for a fault to occur without detection and appropriate action, which must be "fail safe." In other words, the systems must be self-checking.

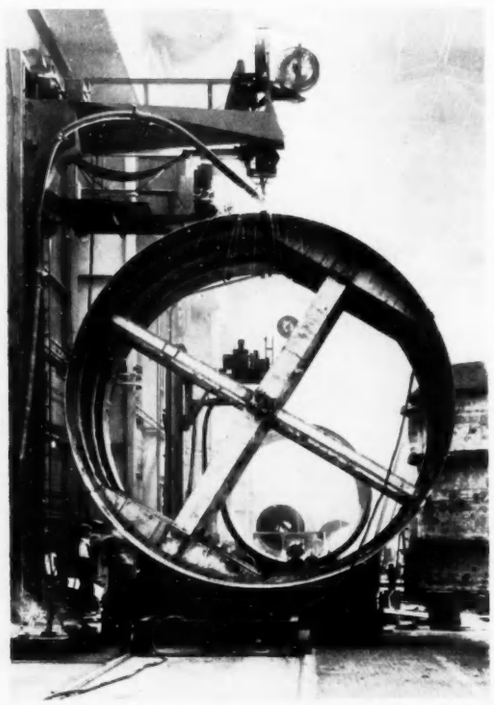
AUTOMATIC INSPECTION

Another paper at the conference concerned the automatic inspection of three-dimensional parts by tape control system. Very broadly, if a measuring head is substituted for a cutting tool, continuous and automatic inspection of physical dimensions can be undertaken provided the measuring head is capable of movement in three co-ordinates. This system has been demonstrated on a Ferranti computer-controlled milling machine. With this it is possible to programme the path of the work so that the stylus is always in contact with the surface. Any divergence from the true programmed path will therefore cause a movement of the stylus which is indicated or recorded.

The sensing head has a stylus which pivots about a lower ball seating and is also capable of vertical movement; at the upper end is a 90° cone in which a ball seats so that any sideways deflection of the stylus point again causes a vertical movement of the final sensing element. In this way both horizontal and vertical surfaces can be checked.

The results obtained have been encouraging. On successive runs on a test piece, results were repeated to within 0·0006 in and the accuracy of results was within 0·002 in when using an ordinary milling machine. Advantages of the arrangement include: speed of inspection; the use of a single machine to check a variety of components; a more comprehensive inspection of the surface; and a permanent record of checks.

WELDING A 93-TON STAINLESS-STEEL COLUMN



Stainless-steel nitric-acid absorption column, 139 ft in height and weighing 93 tons, erected at the Wilton Works of Imperial Chemical Industries Limited.

A vertical nitric acid absorption column now in service at the Wilton Works of Imperial Chemical Industries Limited is stated to be one of the largest stainless-steel vessels ever to be welded. It weighs 93 tons, has an overall height of 139 ft, and a diameter of 15 ft. The tower was fabricated by Ashmore, Benson, Pease and Company, Limited, Stockton-on-Tees, and the material used throughout was an austenitic stainless steel of the 18 : 8 : 1 type.

The shell was made of three sections of differing plate thicknesses. For the lower portion measuring 14 ft 9 in, material of $\frac{5}{8}$ in thickness was employed while the central and remaining portions were made of material $\frac{3}{8}$ in thick. The hemisphere forming the upper end of the vessel was also of $\frac{3}{8}$ in material and was constructed from 12 segments and a crown. The hemisphere for the lower end was similar but was made up of 10 segments and a crown; the plate thickness was $\frac{5}{8}$ in and both ends were thus of the same thickness of material as the section of shell to which they were joined. The supporting base rings and skirt were of $1\frac{1}{2}$ in, and $\frac{3}{4}$ in thick material, respectively.

The welding was carried out with equipment provided by Quasi-Arc Limited, Bilston, Staffs., and Fusarc automatic machines utilising Staymec No. 1 continuous electrodes were employed for the automatic welding of the vessel. Fabrication was conducted in a series of sub-assemblies approximately 15 ft long, in order to make the fullest use of an internal welding boom for automatically welding the internal seams. For external welding, a Fusarc head mounted on a universal type of cantilever was employed and beneath this the vessel was mounted on a roller bed and rotated for the circumferential seams and traversed for the longitudinal seams.

The internal welding boom was of the fixed type and is specifically designed for welding internal longitudinal and, in conjunction with the roller bed, the circumferential seams of vessels having a minimum diameter of 2 ft and up to 15 ft in length. Incorporated in the boom is an automatic welding head and a cradle in which the operator lies prone. A panel in front of the operator gives complete control over the welding operation and, if necessary, over the welding speed, as the roller bed may be rotated or traversed remotely by means of push-buttons on the control panel.

External stiffening rings were employed to maintain concentricity while the welding was in progress and these were left on each sub-assembly until internal cruciform tray supports had been fitted, after which the external rings could be removed.

The vessel was conveyed to the site by road and the 18-mile journey to Wilton took $2\frac{1}{2}$ days to complete. For the erection of the vessel, special lifting links were fitted to a trunnion placed in bearings welded to the column. The lifting of the column was achieved by two 105 ft high derricks each equipped with an electrically-operated winch and a set of blocks coupled to the links at the ends of the trunnion. A crane was employed to take the tail-end load, the crane travelling towards the foundation block as the column was lifted. When the column was in a vertical position, it was lowered on to the foundation block. Twenty-four specially-designed $2\frac{1}{4}$-in diameter holding-down bolts which had been placed in position beforehand were then drawn through the base plate and secured. The foundation block was approximately 30 ft square, 10 ft deep and 525 tons of concrete were utilised in its construction.

When the alignment was subsequently checked, the column was found to be quite vertical in the north to south direction and to within $\frac{1}{4}$ in of the vertical in the east to west direction.

NOTICES OF MEETINGS

British Computer Society

LONDON
"Use of an Electronic Computer in Research Statistics: Four Years' Experience," by Dr. Frank Yates. Caxton Hall, off Victoria Street, S.W.1. Mon., 21 April, 6.15 p.m.

British Institution of Radio Engineers

LONDON
"Factors in the Design of Airborne Doppler Navigation Equipment," by E. G. Walker. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Tues., 15 April, 6.30 p.m.*
CHELTENHAM
"The Automatic Factory," by J. A. Sargrove. South Midlands Section. North Gloucestershire Technical College, Cheltenham. Fri., 25 April, 7 p.m.
GLASGOW
Annual General and Display of Technical Films. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Thurs., 17 April, 7 p.m.

British Nuclear Energy Conference

LONDON
"Operational Experience at Calder Hall," by K. L. Stretch. Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. Wed., 16 April, 5.30 p.m.*

Building Centre

LONDON
Films: "Forming of Metals," exhibited by Shell-Mex and B.P. Ltd. Wed., 16 April, 12.45 p.m.

Chemical Society

BRISTOL
"Water Repellency," by Professor N. K. Adam. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., 24 April, 5.15 p.m.
ST. ANDREWS
"Some Organic Compounds of the Transition Metals," by Dr. P. L. Pauson. St. Andrews and Dundee Branch. Chemistry Department, St. Salvator's College, St. Andrews. Fri., 18 April, 5.15 p.m.

Combustion Engineering Association

GLASGOW
"Present Practice and the Future of Coal-Burning Equipment," by H. E. Pearsall, at 10.30 a.m. "Future Developments in Steam Generators," by H. A. Cameron, at 2.30 p.m. Grand Hotel, Charing Cross, Glasgow, C.3. Thurs., 17 April.

Illuminating Engineering Society

BATH
Annual General Meeting. Bath and Bristol Centre. Offices of the South Western Electricity Board, Bath. Mon., 21 April, 7 p.m.
LIVERPOOL
Annual General Meeting. Liverpool Centre. Liverpool Passenger Transport Office, 24 Hatton Garden, Liverpool, 3. Tues., 15 April, 6 p.m.
MANCHESTER
Annual General Meeting and Members' Night. Manchester Centre. Offices of the North Western Electricity Board, Town Hall, Manchester, 2. Thurs., 17 April, 6 p.m.*
SHEFFIELD
Annual General Meeting. "Contribution of Plastics to Lighting Practice," by W. E. Harper. Sheffield Centre. Grand Hotel, Sheffield. Mon., 14 April, 6.30 p.m.

Incorporated Plant Engineers

BLACKBURN
"Work Study in the Smaller Factory," by P. A. Gibbs. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., 17 April, 7.30 p.m.
CARDIFF
"Effects of Steam Peaks," by Dr. E. G. Ritchie. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 22 April, 7.15 p.m.
COVENTRY
Film: "Taking the Load." Birmingham Branch. Hotel Leofric, Coventry. Tues., 22 April, 7.30 p.m.
DARTFORD
"Jointings," by W. E. Hoes. Kent Branch. Railway Hotel, Dartford. Wed., 16 April, 7 p.m.

Institute of Fuel

LONDON
Presidential Address by H. McNeil. Institution of Civil Engineers, Great George Street, S.W.1. Wed., 23 April, 6.30 p.m.*
NEWCASTLE UPON TYNE
Annual General Meeting. North Eastern Section. King's College, Newcastle upon Tyne. Mon., 14 April, 6.30 p.m.
NOTTINGHAM
Annual General Meeting and Film Evening. East Midland Section. Gas Board's Showrooms, Nottingham. Thurs., 17 April, 6.15 p.m.

Institute of Marine Engineers

LONDON
"Supercharged Boilers for Marine Application," by E. L. Daman. Tues., 15 April, 5.30 p.m.*
Annual General Meeting. Tues., 22 April, 5.30 p.m.*
Discussion on "Marine Machinery Breakdowns," opened by J. H. Milton. Thurs., 24 April, 5.30 p.m.*

Institute of Physics

LONDON
"High-Speed Radiography"—"Tubes and Mechanisms," by R. F. Thumwood; and "Circuits and Evaluation," by R. Meakin. Fri., 18 April, 6 p.m.*
ABERYSTWYTH
"Rock Magnetism and the Wandering of Continents," by Professor P. M. S. Blackett. South Wales Branch. University College of Wales, Aberystwyth. Fri., 25 April, 8 p.m.

Institute of Road Transport Engineers

LONDON
"Adaptation of Commercial Vehicles for Use in a Special-Purpose Mixed Fleet," by R. H. R. Hacker. Royal Society of Arts, John Adam Street, Adelphi, W.C.2. Thurs., 17 April, 6.30 p.m.*
CAMBRIDGE
Annual General Meeting. Eastern Centre. Golden Hind Hotel, Cambridge. Tues., 15 April, 7 p.m.
LEEDS
Annual General Meeting. Yorkshire Centre. Great Northern Hotel, Wellington Street, Leeds, 1. Thurs., 17 April, 7.30 p.m.
MANCHESTER
Annual General Meeting. East Regional Centre. Houldsworth Hall, 90 Deansgate, Manchester. Mon., 14 April, 7.30 p.m.
PRESTON
Annual General Meeting. North Regional Centre. Victoria and Station Hotel, Preston. Wed., 16 April, 7.30 p.m.

Institution of Chemical Engineers

BIRMINGHAM
"Synthetic Rubber Plants," by A. E. W. Bailey. Midlands Branch. Midland Institute, Paradise Street, Birmingham. Wed., 16 April, 6.30 p.m.

Institution of Civil Engineers

LONDON
"Construction of Circulating Water Pump House at Cowes Generating Station, Isle of Wight," by R. H. Coates and L. R. Slade. Tues., 15 April, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
Discussion on "The Future Trend of Installation Inspection," opened by Forbes Jackson. Mon., 14 April, 5.30 p.m.*
"A Train Performance Computer," by Professor E. Bradshaw, M. Wagstaff and F. Cooke; "The Simulation of Distributed-Parameter Systems, with Particular Reference to Process Control Problems," by J. F. Meredith and E. A. Freeman; and "A Magnetic-Drum Store for Analogue Computing," by Dr. J. L. Douce and Dr. J. C. West. Measurement and Utilization Sections. Tues., 15 April, 5.30 p.m.*
"2/1 Pole-Changing Motors," by R. F. Burbidge; "Project Considerations for Diesel-Electric Traction," by R. S. Wignall; and "Some Applications of Mercury-Arc Rectifiers," by A. Wren. Utilization Section. Thurs., 17 April, 5.30 p.m.*
BELFAST
"An Asymmetrical Induction-Motor Winding for 6 : 3 : 2 : 1 Speed Ratios," by Professor G. H. Rawcliffe and B. V. Jayawant. Northern Ireland Centre. Civil Engineering Department, David Keir Building, Queen's University, Belfast. Tues., 15 April, 6.30 p.m.
CARDIFF
"Cathodic Protection," by L. B. Hobgen, K. A. Spencer and P. W. Heselgrave. Western Centre. South Wales Institute of Engineers, Park Place, Cardiff. Mon., 14 April, 6 p.m.*
EDINBURGH
"Mechanical Strength of Power Transformers in Service," by E. T. Norris. South East Scotland Sub-centre. Carlton Hotel, North Bridge, Edinburgh. Tues., 15 April, 7 p.m.
LOUGHBOROUGH
Discussion on "The Application of Digital Techniques to Control." East Midland Centre. Loughborough College, Loughborough. Tues., 15 April, 6.30 p.m.*
NEWCASTLE UPON TYNE
Annual General Meeting at 6.15 p.m. Conversazione at 7 p.m. North Eastern Centre. Royal Station Hotel, Newcastle upon Tyne. Mon., 14 April.

Institution of Engineering Designers

NEWCASTLE UPON TYNE
"Turbo-Car Progress," by P. A. Phillips. North East Branch. Northern Architectural Association, 6 Higham Place, Newcastle upon Tyne. Mon., 14 April, 7.15 p.m.

Institution of Heating and Ventilating Engineers

LONDON
Annual General Meeting and Presidential Address. Federation of British Industries, 21 Tothill Street, Westminster, S.W.1. Wed., 16 April, 6 p.m.

Institution of Locomotive Engineers

LONDON
"Steels for Railway Purposes," by J. E. Roberts and J. Dearden. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, S.W.1. Wed., 16 April, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Three papers on "Petrol Injection," by Errol J. Gay, E. W. Downing, and H. Heinrich and H. Stoll. Tues., 15 April, 4.30 p.m.
Discussion on "Training in Engineering Design," Applied Mechanics Group. Thurs., 17 April, 6 p.m.
Annual General Meeting. (Corporate Members only.) Fri., 18 April, 6 p.m.*
BIRMINGHAM
"Some Experimental Studies of the Mixing Processes and Flow Configurations in Two-Cycle Engine Scavenging," by W. Rizk. Midland Branch. James Watt Memorial Institute, Great Charles Street, Birmingham. Thurs., 17 April, 6 p.m.*
SWANSEA
"Management Control of Small Engineering Firms," by L. Fontaine, J. W. Walker and W. R. Spencer. South Wales Branch. Offices of the South Wales Electricity Board, The Kingsway, Swansea. Tues., 22 April, 6 p.m.

Institution of Mining and Metallurgy

LONDON
"Apparent Viscosities of Heavy Media and Driessen Cone," by E. O. Lilge, T. E. Fregren and G. R. Purdy; and "Scientific Management Principles Applied to West African Mining," by H. H. Fraser and O. E. A. Somerset. Geological Society, Burlington House, Piccadilly, W.1. Thurs., 17 April, 5 p.m.*

Institution of Production Engineers

NEWCASTLE UPON TYNE
Annual General Meeting and Tour of the College. Newcastle upon Tyne Section. Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne. Mon., 14 April, 7 p.m.
PETERBOROUGH
"Paints and Finishes," by E. C. Faulkner. Peterborough Section. Conference Room, Peterscourt, Peterborough. Tues., 15 April, 7.30 p.m.
WOLVERHAMPTON
"Further Review of Electronic Control in Industry," by E. Heys. Wolverhampton Section. Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton. Wed., 16 April, 7.30 p.m.

Institution of Public Health Engineers

LONDON
"Pollution of Underground Water," by Dr. G. Carter, Caxton Hall, off Victoria Street, S.W.1. Wed., 16 April, 6 p.m.

Institution of the Rubber Industry

CARDIFF
Annual General Meeting. South Wales and Monmouthshire Section. Angel Hotel, Cardiff. Mon., 14 April, 7.30 p.m.
MANCHESTER
Annual General Meeting and Social Evening. Manchester Section. Engineers' Club, Albert Square, Manchester. Mon., 14 April, 6.45 p.m.
SOUTHAMPTON
Annual General Meeting and Film Evening. Southern Section. Polygon Hotel, Southampton. Wed., 16 April, 7.30 p.m.

Junior Institution of Engineers

LONDON
"Review of the Activities of the Production Engineering Research Association," by R. L. Hayward. Fri., 18 April, 7 p.m.*

Non-Destructive Testing Society of Great Britain

BIRMINGHAM
"Gamma Radiography," by G. H. Sanders. Birmingham Branch. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2. Sat., 12 April, 10.30 a.m.

Reinforced Concrete Association

LONDON
"Recent Developments in Prestressed Concrete in Belgium," by Professor D. Vandepitte. Institution of Structural Engineers, 11 Upper Belgrave Street, S.W.1. Wed., 23 April, 6 p.m.*

Royal Aeronautical Society

LONDON
"Problems of Vertical Take-Off," by Dr. C. T. Hewson. Section Lecture. Tues., 15 April, 7 p.m.

Royal Meteorological Society

LONDON
Annual General Meeting. Presidential Address: "Transfer Across the Earth's Surface and Through the Air Above," by Professor P. A. Sheppard. Wed., 23 April, 5 p.m.*

Royal Society of Arts

LONDON
"Prestressed Concrete," by G. W. Kirkland. First of three lectures. Mon., 14 April, 6 p.m.

Royal Statistical Society

LONDON
Discussion on "Problems in the Measurement of Price Changes, with Special Reference to the Cost of Living," opened by Dr. S. J. Prais. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Wed., 16 April, 5.15 p.m.*

Society of Chemical Industry

LONDON
Annual General Meeting and Spring Lecture on "Corrosion Research and Its Industrial Background," by W. H. J. Vernon. Corrosion Group. Wed., 16 April, 6.30 p.m.

Society of Instrument Technology

LONDON
Annual General Meeting. "Electronically-Operated Power Plant Instrumentation and Control," by R. E. J. Putman. Control Section. Manson House, Portland Place, W.1. Wed., 16 April, 7 p.m.*
NEWCASTLE UPON TYNE
"Fundamentals of Electronics as Applied to Instruments," by A. L. Anderson. Newcastle Section. King's College, Stephenson Building, Newcastle upon Tyne. Wed., 16 April, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

British Computer Society, 29 Bury Street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
British Nuclear Energy Conference, Great George Street, London, S.W.1. (WHItehall 4577.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institute of Physics, 47 Belgrave Square, London, S.W.1. (BELgravia 6111.)
Institute of Road Transport Engineers, 69 Victoria Street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria Street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehal 4776.)
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Engineering at Home

SKIRTING HEATING

The designers of nuclear reactors are not the only ones with a close interest in heat exchangers. Their design occupies the minds of engineers in many other industries. Naturally, various applications lead to different criteria. In the home, for example, it is not enough for a device to heat the room; it must also be pleasant to look at, easy to clean, and safe. The steps taken to meet these criteria are, in turn, various.

A system that uses heating elements built into the skirting board has recently been put on the market by Copperad Limited, Colnbrook, Bucks. The elements are called "Wallstrip"; three types are produced. Type C, shown in the illustration, is the all-purpose type—it provides mainly convective heating. It uses a heat exchanger that consists of a steel or copper tube that is expanded on to non-ferrous fins, swaged and ribbed for rigidity. Either steel (0·846 in o.d.) or copper ($\frac{3}{4}$ in to B.S. 659) pipes can be supplied. The fins are spaced no closer than five per inch.

Copperad Wallstrip is primarily designed for use on low and medium temperature hot water systems with pumped circulation; but it can be used with steam. The maximum working pressure is 100 lb per sq. in and the thermal emission is greatest when the water velocity in the pipes is kept to a fairly high value. Actual values of emission for various conditions are given in the table.

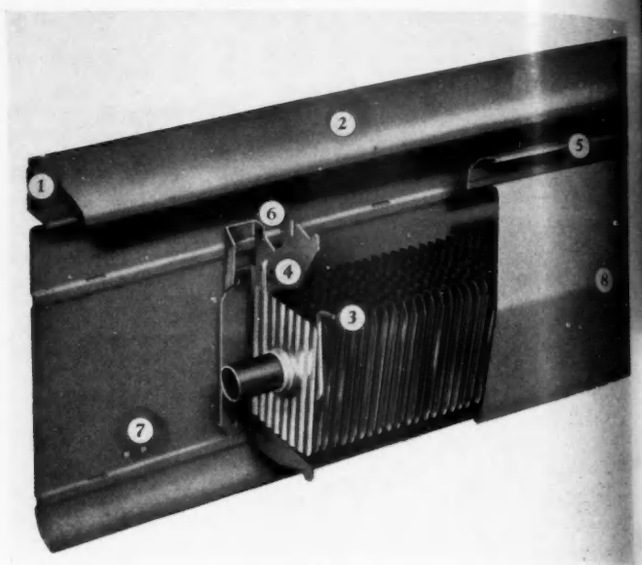
Thermal Emission of Convective "Wallstrip" Type C.

Hot water Mean temp., °F	Ambient temp., °F	Actual emission B.t.u. per hour per ft run	
		Water flow, 500 lb/hour	Water flow, 1,500 lb/hour
150	60	400	430
	65	370	400
	70	340	370
160	60	460	493
	65	430	461
	70	400	430
170	60	520	557
	65	490	525
	70	460	493
180	60	580	622
	65	550	589
	70	520	557
200	60	710	757
	65	677	722
	70	645	688
220	60	850	900
	65	815	864
	70	780	828
240	60	990	1,046
	65	955	1,009
	70	920	972

A complete 8 ft main length of the Wallstrip type C weighs 33 lb, if the tube is of copper. The main element for such a length weighs 8 lb. Thus the system is very light compared with cast-iron heating equipment of similar output. Two 8 ft units, for example, will give an output of about 9,000 B.t.u. per hour, when operating on low temperature hot water, for a weight of 66 lb.

When positioning the strip in the room, it should preferably be fitted along the walls where the greatest heat loss and air infiltration will occur, particularly on exposed walls and below windows. The emission can be matched to the heat requirements of the room, since the Wallstrip is available in sections that can be combined to give active lengths from 3 ft upwards in increments of 1 ft. If it is desired to spread the emission over a greater length than normal, casing parts that only carry flow and return pipework can be used. The equipment has a low thermal capacity and so the heat output varies quickly with the supply water temperature.

The casing is of sheet steel, the rear and top being of roll-formed one-piece construction. By curving the bottom edge at floor level, the firm have provided a coved corner for easy cleaning. The front panel is also of roll-formed section and is snapped into position. Valves are contained in special boxes—full on-off operation is by means of a 90° movement.



The extended surface heating element of "Wallstrip" type C is contained in a sheet metal casing arranged to admit cool air at the bottom and discharge warm air at the top.

1. Foam plastics anti-streak seal.
2. One piece top and back.
3. Hanger to allow elements to expand freely.
4. Element grading is achieved by provision of several holes in the support bracket.
5. Deflector plate.
6. Space for return pipe.
7. Fixing holes.
8. Snap-on front cover.

CLOSE SWITCHES

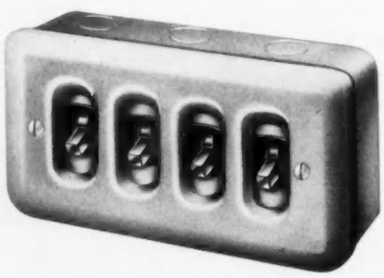
The British Standard flush switch box is at present available only in one size, because B.S. 1299 does not cover boxes larger than one gang. However, in common with other manufacturers, J. A. Crabtree and Company Limited, Walsall, Staffs., have for some years produced a two-gang box. The Crabtree "Closegang" range marks a further development of these standard fixing centres. In addition to the standard one- and two-gang boxes, it will include standard four- and six-gang mode.s. There will thus be four standard boxes.

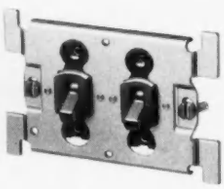
The small size of the accessories has made it possible to double the capacity of the standard box. Crabtree "Closegang" wiring accessories will include 5 A one-way, two-way, intermediate and push switches; 15 A one-way and two-way switches; a neon indicator and a component for blanking purposes. Any or all of these accessories may be included in any one assembly. A large number of different combinations is thus possible.

The accessories are arranged for assembly on yokes, which are then fixed to the box on standard centres. The yokes for flush assemblies, shown in the illustration, align themselves to the plaster level and provide for "out-of-square" adjustment. The yoke-fixing screws are removable and may be exchanged for screws of different length. There is provision for a separate earthing terminal if required. The standard yokes will accommodate one, two, three or four accessories respectively.

Each switch is a complete unit and may be used apart from the Crabtree "Closegang" boxes and plates: they can, for example, be fixed to panels. All switches are sealed against plaster dust and provided with dollies of nylon.

Protected plates will be available, from one to 12-gang, in rustproofed steel finished in oil-resistant quaker grey enamel. Brass plates will also be available in from one to 12-gang for flush or surface mounting.





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ENGINEERING

Published every Friday by ENGINEERING LTD. at 36 Bedford-street, London, W.C.2.
Telephone: Temple Bar 3663.
Telegrams: Engineering Lesquare London.

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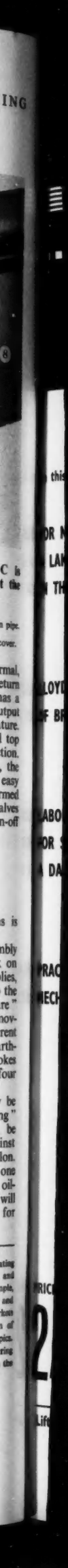
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